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THE ELECTRICIAN:

A WEEKLY JOURNAL OF

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THEORETICAL AND APPLIED ELECTRICITY AND CHEMICAL PHYSICS.

VOLUME I.

From MAY 25, 1878, to NOVEMBER 16, 1878.

LONDON:
Printed and published by JAMES GRAY, at the Office, 396, Strand, in the City and Liberty of Westminster.

1878.

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THE ELECTRICIAN:

A WEEKLY JOURNAL OF

THEORETICAL AND APPLIED ELECTRICITY AND CHEMICAL PHYSICS.

No. 1. SATURDAY, MAY 25, 1878. PRICE 4D.

THE ELECTRICIAN.

The want of a weekly paper devoted to the consideration of Electrical subjects has long been felt, and we venture to attempt to supply the want. The following gentlemen, among others, have promised their aid:—

ADAMS, Prof. W. G., F.R.S.
ANDERSON, Sir JAMES.
ANDREWS, W. S., M.S.T.E.
CLARK, LATIMER, C.E., M.S.T.E.
CUMMING, L., M.A.
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WARREN, THOS. T. P. BRUCE, M.S.T.E.
WHIPPLE, G. M., D.Sc.
WORMELL, R., M.A., D.Sc.
WILSON, W. J., F.C.S.

We shall be glad to receive suggestions from those who are interested in the work, as we desire to meet the wants of readers, and not to carry out rigidly any preconceived ideas of our own. All suggestions will receive careful attention. As a rule, each number of *The Electrician* will contain:—

Notes on electrical and cognate subjects.

Articles of a technical nature.

Articles of a more general character, on subjects bearing directly or indirectly on telegraphic progress. We hope to make this portion of each issue interesting and important to shareholders, and shall keep their interests steadily in view.

Translations and extracts to keep readers *au courant* with the work of the Continent and of America.

Correspondence of a general character, corresponding to the articles of similar nature.

Correspondence of a special and technical nature. Under this head we invite students to send questions on electrical subjects, to be answered by their fellow-readers.

Students' Pages. These pages will be specially written for students, keeping constantly in view that they are not perfect in their knowledge, and do not despise information upon topics which may to others seem worn threadbare.

Reviews of Books. It is a mistake for a student or scientist to be too parsimonious in the matter of literature. There can be no doubt that a good library is a most valuable acquisition. We shall endeavour to give an unbiassed opinion as to the merits or demerits of any work submitted to us by author or publisher.

Reports of Meetings, of Scientific Societies, and of Telegraph Companies.

Abstracts of recent Patents.

NOTES.

OBSERVATIONS ON MAGNETIC DECLINATION AT PRAGUE OBSERVATORY.—In a paper recently read before the Royal Society, Professor Balfour Stewart has exhaustively discussed the bearing of these observations. The record commenced in July, 1839, and has been continued till the present time. A series of well-arranged tables give the results obtained, and, after contrasting these results with sun-spot records, Professor Stewart says: "I have thus examined the most trustworthy sun-spot values and declination ranges, and it may, I think, be fairly concluded that there is an intimate relation between the two phenomena, but that the points of the sun-spot ranges precede those of the declination ranges in respect of time." The Professor then discusses those variations which seem to depend on planetary configurations, and considers respectively the separate and joint actions of Mercury and Jupiter, concluding that theory and observation agree, and that the declination results should be behind the solar results in point of time. "An inspection of the sun-spot records reveals the fact that, at times of maximum spot frequency, not only are there more spots on the sun, but that the sun-spot inequalities or oscillations (however produced) are at such times much more prominent than during times of minimum sun-spot frequency. Now, if it be true that these spot-periods are due in a great measure, if not entirely, to planetary configurations, we might expect that (possibly from an increase in the susceptibility of the sun) the planetary periods herein investigated should at times of maximum sun-spots be found to be greater than their average value. It is a curious and interesting fact that (as far back as accurate observations extend) times of many sun-spots correspond well with times when Jupiter is at the perihelion of Mercury. Now, it is easy to see that on this account alone, and apart from any increased susceptibility of the sun, we should have sun-spot inequalities greater than the average at the times when the two planets are in this position with respect to each other." A series of tables is given to show that the observed planetary inequalities are greater than the calculated. "If we now turn to declination-ranges we shall find that there are greater oscillations or sub-periods in the value of these ranges during times of maximum than during times of minimum sun-spots,

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But, on the other hand, the increased value of such oscillations is by no means so striking as in the case of sun-spots." On treating the inequalities of magnetic declination in a similar manner, and thus taking into account planetary configurations, it is found that the observed inequalities are greater than the calculated inequalities, but not to the same extent as in the sun-spots. Prof. Stewart thinks that this magnetic susceptibility has some light thrown upon it by two facts discovered by Mr. Broun. "The one is that the magnetic influence of the moon on the earth shows traces of following the solar period, this influence being greater during times of maximum than during times of minimum sun-spots. The other is that at Trevandrum the lunar magnetic influence, without changing its type, exhibits an increase of value when the sun is above the horizon at that place, as if on such occasions there were an increase of susceptibility to the lunar influence."

A New Cable Ship.—The Eastern Extension Company has added to the already magnificent fleet of cable ships a new iron vessel, called the *Sherard Osborn*, so named after the celebrated Arctic navigator, who took so great an interest in the laying of cables. The *Sherard Osborn* is moored off the works of the Telegraph Construction and Maintenance Company at Greenwich, preparatory to taking on board cable, and being completely fitted up for the Singapore Station. Next week we hope to give some details of the equipment of the vessel.

Simultaneous Discovery.—It is frequently the case that two or more people discover the same thing independently and almost at the same time. The telephone of Prof. Bell turned the attention of numbers of scientific students to the study of the connection between sound and electricity; and, although Prof. D. E. Hughes has been the first to publish his discoveries in this direction, it is by no means certain that the results have not been previously obtained. We give in this number the investigations of Mr. W. L. Scott, who has, whilst working independently, obtained similar results to those of Prof. D. E. Hughes.

Troubles with the Telephone.—M. Alluard gives an account of the use of the telephone established between the Observatory of Puy-de-Dôme and Clermont-Ferrand. The keeper of the observatory, with all his experience as a manipulator, worked from the first much more quickly with the telephone than with the telegraph. The wire of the telephone runs on the same poles as the telegraphic wires. At the foot of Puy-de-Dôme is a post of artillery, and it is found that no communication can be made without being heard by the artillerymen. This phenomenon is even reciprocal up to a certain point. So the keeper is sometimes obliged to ask his correspondent at Clermont-Ferrand to wait a moment because the brigadier is singing, and his song disturbs the telephonic communication. Thus, in this transmission of sound by electricity, many phenomena remain still unexplained, since sound can reproduce itself without requiring the vibrating diaphragm, by contact with the line wire alone.

The Telephone in Bengal.—The telephone has been tried successfully between Lucknow and Sitapore, a distance of fifty-four miles. Conversations were carried on with different people for a considerable time with the utmost ease, and a clock, which was made to strike near the telephone in the Lucknow telegraph office, was distinctly heard, and its strokes counted, in the office at Sitapore. The instruments used were made by Lieut. H. C. Holden, R.A., Sitapore, who kindly lent them for the experiment.

Vacuum Tubes.—In a paper read before the Royal Society on May 16 on Experiments on the Electric Discharge through Vacuum Tubes, by Warren de la Rue, F.R.S., and Hugo W. Muller, F.R.S., the authors stated that in the course of three-and-half years investigations they had arrived at the following facts:—(*i.*) The discharge in a vacuum tube does not differ essentially from that in air and other gases at ordinary atmospheric pressures; it cannot be considered as a current in the ordinary acceptation of the term, but must be of the nature of a disruptive discharge, the molecules of the gas acting as carriers of electrification. The gases in all probability receive two impulses in opposite directions, that from the negative being the more continuous of the two.* Metal is frequently carried from the terminals and is deposited on the inside of the tube, so as to leave a permanent record of the spaces between the strata. (*ii.*) As the exhaustion proceeds the potential necessary to cause a current to pass diminishes up to a certain point, whence it again increases, and the strata thicken and diminish in number, until a point is reached at which notwithstanding the high electromotive force available, no discharge through the residual gas can be detected. (*iii.*) All strata have their origin at the positive pole. Thus, in a given tube, with a certain gas, there is produced at a certain pressure, in the first instance, only one luminosity which forms on the positive terminal, then, as the exhaustion is gradually carried further it detaches itself, moving towards the negative, and being followed by other luminosities, which gradually increase in number up to a certain point. (*iv.*) With the same potential the phenomena vary irregularly with the amount of current. Sometimes, as the current is increased, the number of strata in certain tubes increases, and as it is dimished their number decreases; but with other tubes the number of strata frequently increases with a diminution of current. (*v.*) A change of current frequently produces an entire change in the colour of the strata. For example, in a hydrogen tube from a cobalt blue to a pink. It also changes the spectrum of the strata; moreover, the spectra of the illuminated terminals and the strata differ. (*vi.*) If the discharge is irregular and the strata indistinct, an alteration of the amount of current makes the strata distinct and steady. Most frequently a point of steadiness, sufficient for photographing, is produced by the careful introduction of external resistance; subsequently the introduction of more resistance produces a new phase of unsteadiness, and still more resistance another phase of steady and distinct stratification. (*vii.*) The greatest heat is in the vicinity of the strata. This can be best observed when the tube contains either only one stratum, or a small number separated by a broad interval. There is reason to believe that even in the dark discharge there may be strata; for we have found a development of heat in the middle of a tube, in which there was no illumination except on the terminals. (*viii.*) Even when the strata are to all appearance perfectly steady, a pulsation can be detected in the current; but it is not proved that the strata depend upon the intermittence. (*ix.*) There is no current from a battery through a tube divided by a glass division into two chambers, and the tube can only be illuminated by alternating charges. (*x.*) In the same tube and with the same gas, a very great variety of phenomena can be produced by varying the pressure and the current. The luminosities and strata, in their various forms, can be reproduced in the same tube, or in others having similar dimensions. (*xi.*) At the same pressure and with the same current, the diameter of the tube affects the character and closeness of the stratification.

* "Phil. Trans.," Part I, vol. clxix, pp. 90 and 118.

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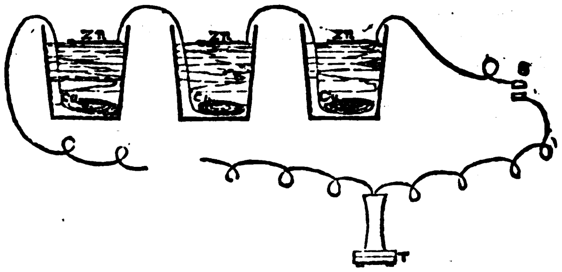
PROFESSOR D. E. HUGHES'S TELEPHONE, MICROPHONE, AND THERMOPILE.

Among the many wonderful discoveries of the nineteenth century, this one of Professor Hughes must take a very high position. We are inclined to think that one or two points in connection with this discovery may be overlooked, and, although the discoverer will receive a large share of praise and honour, it will fall short of what he deserves unless we take into consideration the way in which the discovery was achieved. It was no mere chance that led Professor Hughes to investigate. He started with a complete knowledge that certain effects followed from certain causes, and reasoned that similar causes should produce equally certain effects. There was no swinging of a lamp, or prick of a pin, or muscular contraction—no accidental directive force—to excite attention; the result seems to have been obtained by a use of inductive reasoning. Heat is a mode of motion; sound is produced by motion; heat has a certain effect upon the electric current; and probably, Prof. Hughes reasoned, sound has also as certain an effect upon the current. Having arrived at this conclusion, Professor Hughes proceeded to experiment as to the best method of obtaining this effect. We shall in this paper describe as clearly and concisely as possible the apparatus used, so that readers may investigate into the phenomena for themselves, and we have no doubt a mass of facts will be forthcoming shortly, and shall do our best to give them prominence.

The results obtained by Professor Hughes have been obtained by means of very roughly-made apparatus. His battery consists of three small tumblers, as shown in Fig. 1, containing a

FIG. 1



coil of copper at the bottom, on which is placed some sulphate of copper, and then the glass is almost filled with clay well moistened with water. The negative pole consists of a strip of zinc lying in the clay. This battery has a large internal resistance. It has been in use several months, but continues to work admirably. The circuit includes a home-made telephone, made thus:—A small bar magnet 4in. long, half the coil of an electro magnet, and a square piece of ferrotype iron 3in. square, clamped rigidly in front of one pole of the magnet between two pieces of board. A telephone is always used as the receiving instrument, it being the nature of the transmitter that Professor Hughes has so elaborately investigated. The transmitter is at some other point, say S in the circuit.

The first investigations of Professor Hughes will best be explained in his own language:—"I introduced into the circuit at S (*vide* Fig. 1) a strained conductor, a stretched wire, listening attentively with the telephone to detect any change that might occur when the wire was spoken to or set into transverse vibrations by being plucked aside. Gradually, till the wire broke, the strain was varied, but no effect whatever was remarked except at the moment when the wire broke. The effect was but momentary, but invariably at the moment of breaking a peculiar 'rush' or sound was heard. I then sought to imitate the condition of the wire at the moment of rupture by replacing the broken ends and pressing them together with a constant and varying force by the application of weights. It was found that, if the broken ends rested upon one another with a slight pressure of not more than one ounce to the square inch on the joints, sounds were distinctly reproduced, although the effects were very imperfect." The next act was to find means to produce the sound other than by the breaking of the wire, and to find a substance or a combination of substances which, when influenced by sound waves, would transmit the sound to the telephone. The professor found that, if he filled a small glass tube with a mixture of tin and zinc, known as "white bronze," plugged the ends with pieces of carbon, and connected the whole, as in Fig. 2, with a galvanometer in circuit, on slightly pressing the carbons, and thus compressing the metallic particles, he obtained a deflection in one direction, whilst on exerting a tensile strain on the glass, and thus slightly expanding the space occupied by the metallic particles, he obtained a deflection in the other direction. On compressing the metallic particles they are brought into closer and better contact, and the total resistance of the circuit is decreased, but, on the contrary, when the particles are farther apart, the electric contact is not so good, and the resistance is increased. Now, it will easily be seen that the

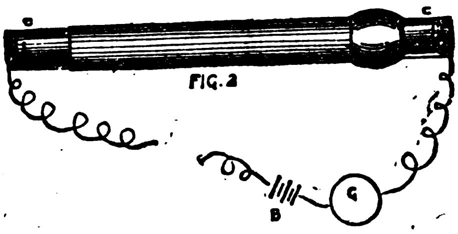
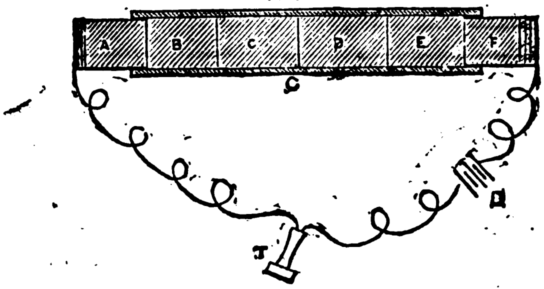


FIG. 2

increased and decreased resistances influence the current, decreasing it in the one case, increasing it in the other, and, as the current influences the magnetism of the magnet which acts upon the diaphragm of the receiving telephone, the modulations of sound causing action at the transmitting end are reproduced at the receiving end. Another transmitter of Professor Hughes, shown in Fig. 3., is described as follows:—"The tube transmitter con-

FIG. 3



sists of an exterior glass tube two inches long and one quarter of an inch in diameter. In it are four separate pieces of willow charcoal, each one a quarter of an inch long, and two terminals of the same material. The terminals are fastened in the tube and connected externally with the line, and internally with the four loose pieces. In this case A is made to press on B, C, D, E, and F, until the resistance offered to the electrical current is about one-third that of the line upon which it is to be employed. It may be attached to a resonant board by the ends A or F. If the result were simply due to vibrations, we should have A and B making greater contact at a different time from E and F, and consequent interference. If it were a simple shaking or moving of B, C, D, E, and F, it could produce no change, as, if B pressed more strongly on C, it would be less on A, and also, if the tube were attached by the centre, we should have no effect; but, if the effect be due to a swelling or enlargement of B, C, D, E, and F, it would make no difference where it is attached to the resonant-board, as is actually the case. Again, reduce the pressure of A upon B, &c., until they are not in contact, and no trace of current can be perceived by shaking the tube. The instant the sonorous vibrations pass in the tube there is electric contact to a remarkable degree, which could only have taken place by the molecules enlarging their sphere under the influence of the sonorous vibrations." But it was soon found that a complicated piece of apparatus as transmitter was unnecessary. Two parallel nails in circuit, with contact made by a third nail, or piece of watchspring, or coin forms a good transmitter. Fig. 4.

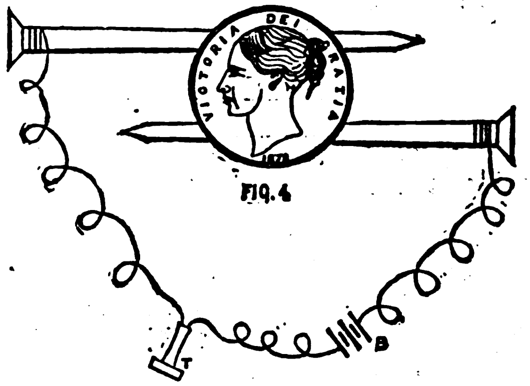


FIG. 4

The most delicate piece of apparatus to which the name of *microphone* has been given is thus made. A cylindrical piece of carbon is metallised by being heated white hot and plunged under mercury, when, the pores being filled with the metal, causes the almost non-conductor to become a fairly good conductor. The carbon may be metallised with iron with equally good results. A piece of this metallised carbon is taken and pivoted at its centre,

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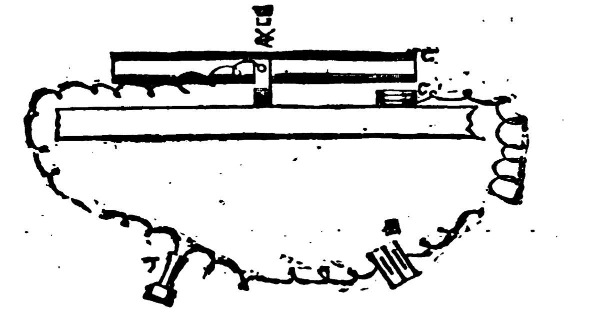
so as to be ***delicately balanced*** and attached to a resonant board as in figures 5 or 6. The most sensitive form is that shown in



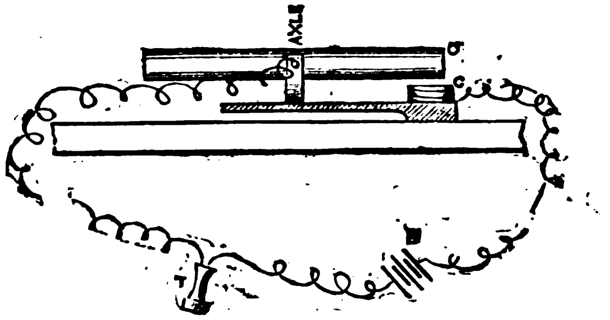
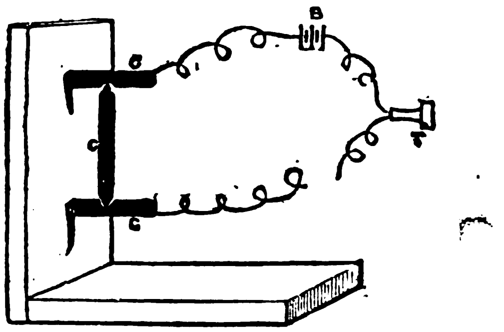


figure 6. Another piece of carbon is fixed to the board as shown in the figure. These carbons are severally attached to the two poles of the battery, and the circuit is completed when the carbon rod rests upon the other carbon. "The object in pivoting the carbon at or very near the centre is to ensure contact only; the lighter the contact the more sensitive is the instrument to the sonorous waves." It is with this transmitter that the tramp of a common house fly is distinctly heard. The fly, placed in an ordinary match box partially covered with gauze, walks about from point to point to find an outlet by which to escape. The box is placed on the resonant board, and then the listener at the telephone can, as we say, distinctly hear the tread of the fly. We believe that the physician will, when the form of the instrument is modified, find in it one of the greatest aids that science has discovered to help him to distinguish the natural from the diseased sounds produced by the lungs and heart of his patient. Its sensitiveness is wonderful. The tones of the voice are augmented. The speaker need not put his mouth close to the instrument, yards may intervene, but the sound is clearly transmitted. If the speaker is too close the sounds received are harsh and disagreeably loud.

Another form of this instrument, perhaps more delicate still, is given in Fig. 7. This, indeed, seems to approach the con-

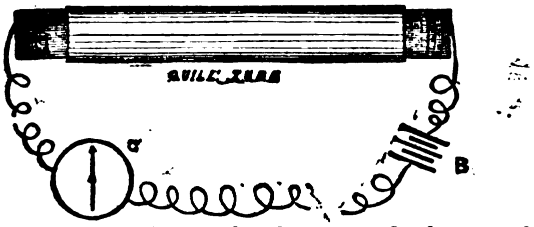


fines of perfection. A stick of metallised carbon is supported between two other pieces of carbon, as in Fig. 7. The upright board and the base board in Professor Hughes's experimental apparatus consist of two pieces of mahogany obtained, we fancy, from an empty cigar box. It does not matter at which end of the supporting carbons the connections are made.

We are informed that the proprietors of the *Daily News* connected their office with the House of Commons by means of a telephonic circuit, but unfortunately the telephones would never act. We are almost inclined to say that the introduction of Professor Hughes's apparatus as a transmitter would obviate all danger of failure. At any rate, if there is no defect in the wires, or in the battery, or in the contacts, we feel confident that this instrument would faithfully transmit the words uttered in the House to the shorthand writer in Fleet-street. The great drawback would be that it would transmit the cheers and counter-cheers and all the hubbub of which the outside world is supposed to be ignorant. It is found that conversation can be carried on from both ends of the line at the same time, but, singular to say, the telephone at your ear will not give the sounds uttered by you, it gives only those uttered at the other end of the line. During some experiments we tried various ways to produce interference, but unsuccessfully. The duplex system worked admirably, and we have little doubt that triplex or quadruplex or almost any other multiplex will be found possible, but that the resulting sounds will be confused and unintelligible.

Besides its use in telegraphy, and in medicine, this discovery of Professor Hughes will place in the hands of the physicist an extremely sensitive thermo-pile. Instead of the glass tube, as described in Fig. 2, Professor Hughes was experimenting with a quill tube, Fig. 8, and found that the instrument was

FIG. 8.



exceedingly sensitive to heat. On the approach of a warm hand the galvanometer needle swings violently in one direction; on cooling the tube it swings in the other. We have seen Professor Hughes place a small French clock near the apparatus, and the motion of the clock generated heat sufficient to cause the swinging of the needle, and, on allowing the small bell of the clock to strike, the needle swung violently as far as it could go. We have said enough to show the delicacy of all these instruments, but we must inform readers that these results have been obtained not with materials manufactured in the best possible way, but with materials taken from whatever source happened to be at hand, and put together in the roughest manner. Professor Hughes has declined to patent his inventions, but gives them, with whatever value they possess, to the world.

ON PHONOPHONIC SUBSTANCES AND THE MAGNOPHONE.

BY WENTWORTH LASCELLES SCOTT, A.S.T.E., LECTURER ON CHEMISTRY AND PHYSICS TO THE LONDON CONSERVATOIRE OF MUSIC, ETC.

For some time past, during the uncertain intervals available for private research amidst the exigencies and duties of professional life, I have devoted very considerable attention to the relations naturally existing between sound and electricity, and also between the latter force and light. It is the remarkable results already obtained in the first division of this necessarily conjugate subject that I desire to lay before the readers of *The Electrician* upon the present occasion.

Fascinated, as so many others have been, by the telephones of Reiss, Dolbear, Edison, and Bell, I sought diligently in the course of these investigations, for some practical development of the instrument in question which should rescue it from that oblivion to which all mere scientific toys are, sooner or later, consigned, with the avowed object of producing a "telephone" capable alike of diminishing or of largely increasing the intensity of the sounds conveyed thereby. Omitting all needless details, it may be briefly noted that my first distinct improvements upon the ordinary magneto-electric telephone were obtained by modifying the diaphragm or vibrating armature of this instrument: thus it was of course quickly found that, *cœteris paribus*, the greater the weight of metal caused to vibrate by the impact of sonoric waves the louder was the sound emitted at the "listening end," although frequently at the expense of *clearness*. Increased *definition*, however—if I may be allowed to import a convenient *optical* term—was obtained by the simple expedient of avoiding the insensitiveness of heavy and therefore more rigid diaphragms, by employing a number of thin laminæ in place of one thick plate, and this arrangement is so far a practical improvement that instruments provided with five such vibrating plates (the outer four having central apertures) will receive and emit clearly a variety of sounds for which in the ordinary "Bell Telephone" there is simply "no thoroughfare."

From several armature-plates to a considerable number would be a natural step except for the weaker effect produced on each by those which are farthest from the magnet. Recourse was had, therefore, to other expedients (using sometimes a voltaic

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The hanks are then gauged, and divided according to the diameter of the wire into as many heaps as there are sizes of wire. This facilitates the testing, and gives at once an idea of what the average weight of the conductor will be in the completed core. At one time it was the practice with copper wire drawers to bind each hank by twisting the outside end several times around the coil; but separate binding wires have recently been adopted, which is a great advantage in every respect. In this case the test may be made with wire a very little distance from the extremity of a hank.

The wire when tested is passed on to another man, who coils it up, and refastens it, three or four hands being required to get through the number above mentioned.

The cable or core manufacturer's specification for the copper wire manufacturer stipulates the exact size to which the wire should be drawn, but, as the holes in the drawplates get larger by use, it is necessary to allow a slight margin on both sides of the exact diameter. Manufacturers can easily work to an exact mean by allowing on wires of the usual size for stranded conductors a variation of ·001 of an inch above and below the specified diameter. As the hole becomes larger, a slight hammering reduces them to the required size before drawing a fresh wire through them.

The price paid for the wire varies with the length each hank is to contain, and the men who are employed to draw the wire generally receive a premium of so much per pound on long hanks, short hanks of wire being charged a trifle less than the larger ones. Long hanks of No. 22 B.W.G. will contain from three-quarters of a mile to a little over a mile in length. There is not much advantage gained by being too long for stranded conductors, since the bobbins of the stranding machine will contain only a limited quantity.

I have generally found that wires of small size have a higher conductivity than those of larger diameter; thus No. 16 copper wire of best quality will vary from 96 to 97 per cent. in conductivity that of pure copper, whereas No. 22 wire is easily obtained as high as 98 to 99 per cent. I have repeatedly tested No. 22 wire, where the variation in conductivity has been much less than 1 per cent. between the different hanks tested; and giving an average of 97·5 per cent. the conductivity of pure copper.

Copper wire manufacturers have shown great zeal in improving the quality of telegraph copper. I believe the secret of the improvement lies in the fact that those ores are selected which contain the smallest amount of metallic impurities, rather than in any alteration in the smelting and refining or annealing processes.

I hope on a future occasion to deal with the chemical portion of this subject, for it is by no means certain that copper wire, electrically approaching *purity*, can be chemically regarded as such.

In order to obtain copper for the production of standards, the electrolytic method is adopted, but precaution must be taken to ensure the absence of such impurities as might be deposited by electrolysis.

As copper wire is not a convenient or reliable metal for constructing standards, the best plan is to content one's-self with a copy from some authenticated coil. A convenient form is a resistance corresponding to that of 100 inches of wire weighing 100 grains. A more certain result is obtained by measuring the resistance itself of some good length of the wire, say for No. 22 B.W.G. about 200 yards carefully coiled on an insulated drum, the whole being allowed to stand for some hours in the same room as the resistance coils used for measuring. The hank thus tested is retained as the standard wire. The conductivity of this wire may be then obtained from the following figures given by Mr. Latimer Clark :—

Resistances of copper wire weighing 1lb. per N.M.:

Temp. 32° F. 1091·22 B.A. units
" 60° " 1155·48 " "
" 75° " 1192·33 " "

If we start with a wire weighing 16lbs. per nautical mile, and coil on our drum 203 yards ($\frac{1}{10}$ N.M.), we should have a resistance of 7·45 B.A. units—74·5 per N.M. With instruments of ordinary sensibility this resistance can be safely adjusted to $\frac{1}{100}$th part of a unit.

If, instead of getting a balance with 7·45 units, we require to plug in 7·50 units, we obtain by a simple proportion the conductivity of our standard :—

7·50 : 7·45 : : 100 : 99·3

The hank thus tested should be carefully wrapped up to avoid tarnishing, and if carefully used will last for years.

The following is the form of the apparatus with its latest improvements, which I have employed for all sizes of wire up to No. 16, B. W. G. For thicker wires it is best to use two drums grooved to receive the wire.

A mahogany board A B is clamped at its ends. It should be of well seasoned wood and polished, so as to avoid any chance of warping or twisting. It is divided as shown in the figure, and one of its parts, being made to slide in or out, enables it to be lengthened for any size wire required to be tested. A stout thumb-screw keeps the moveable part in its place when adjusted.

The part B has fixed to it a stout block of brass, to which are soldered two stout flat pieces of copper, about half a metre in length, and carefully graduated into millimetres. The brass block has three strong terminals 1, 2, 3. On each of the graduated copper bars is a sliding terminal, making good contact, but clearing the wire stretched above the bar until the terminal is screwed down. These terminals should slide evenly along, and the edge on one side must accurately concide with the portion of the terminal in connection with the wire at its point of *electrical division*. These terminals serve to divide the wire on either side, so as to produce equilibrium, and the length thus cut off is at once read in mm.

The part A carries three well insulated brass blocks C, D, E, each of which is supplied with three good binding screws. The connections are made as shown. The battery used is a large Daniels' Element with plates about 18″ square. The galvanometer is of the ordinary reflecting description, with a tripod support, and wound with a few yards of rather thick well insulated copper wire. The resistance being about ·1 to ·5 B.A. units. This arrangement with the most ordinary care allows the adjustment to be made rapidly to within a few mm., or $\frac{1}{1000}$th part of the total resistance to be adjusted. A damper should be attached to the needle of the galvanometer, which, of course, in this case is not astatic.

F and F′ are two coils of the standard wire equal in length to that of the standard itself, clamped between the terminals on A to the blocks C, D, E, as shown.

V and V′ are two ebonite blocks, grooved so as to prevent the wires from stretching by their own weight when A and B are required to be drawn a great distance apart.

As the sliding contacts do not move along the wires there is no possibility of affecting their calibre, which is the great objection to adjusting by means of the divided wire arrangement.

We start with three branches of the balance equal to one another, and, by selecting the standard as before pointed out, the adjustment of the fourth branch is to establish an equality in all the four branches. In this way the sensibility of measuring becomes greater as we approach the final adjustment.

A key is connected between the battery and the middle terminal of the block D. The heating effect is reduced by making the contacts very short, and, as all the resistances may be made nearly equal before starting, there is not much fear of incurring an error through the unequal heating of the branches.

The metal blocks and divided bars are all carefully insulated with ebonite. The hank or coil of wire rests on an insulating sheet of india rubber or gutta percha.

If the sliding contact is not used on the standard, the slight tarnishing which takes place may be neglected.

To explain the application of this arrangement, we will suppose that it is required for testing copper wire ·033′ dia., and, from what has been previously pointed out, we will assume the variations to be ·037′ and ·039′ for the limits on both sides. We deal with these figures as whole numbers, and obtain their squares and the differences of their squares from the highest number :—

·037′ diar.	$37^2 = 1{,}369$	152
·038″ "	$38^2 = 1{,}444$	77
·039″ "	$39^2 = 1{,}521$	

We select a standard coil or hank of the highest conductivity we are likely to meet with, and, by taking the largest diameter it is intended to accept, we have merely to alter the lengths on one side, and which will contain the lengths to be examined.

With wire of the same conductivity these numbers give at once the lengths required to balance the standard, and consequently no further calculation is involved. But, if the standard is selected equal to 99 per cent., that of pure copper, and we have to accept a specified conductivity of 93 per cent., we have only to tabulate in addition to the above the lengths and differences corresponding to this difference in per centage. Thus :—

	Length standard.	Length standard of 93 per cent.	Differences for conductivity. Standard.	Differences for conductivity. 93 per cent.
·037″ diar.	$37^2 = 1{,}369$ m.m.	1,286 m.m.	152 m.m.	235 m.m.
·038″ "	$38^2 = 1{,}444$ "	1,356 "	77 "	165 "
·039″ "	$38^2 = 1{,}521$ "	1,429 "		92 "

Reference to the following table for intermediate values of conductivity will shew the simplicity and ease with which wire may be tested on this plan :—

Dia.		Length corresponding to standard for different conductivities. 99°/o	93°/o	97°/o	96°/o	95°/o	94°/o	93°/o
·037″	37^2	1,369	1,355	1,341	1,327	1,312	1,303	1,285
·038″	38^2	1,444	1,429	1,415	1,400	1,384	1,371	1,356
·039″	39^2	1,521	1,506	1,490	1,475	1,458	1,444	1,429

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The mean difference for $1_0 f^0$ in conductivity being 15 m.m., it is sufficient in practice to move the sliding contact 14 or 15 m.m. at a time, when by simple inspection of the table it will be at once evident what the quality of the wire is.

It is first necessary to ascertain that all the connections are clean and perfect. The best way to do this is to insert an equal length of the standard wire into each branch of the arrangement, and to find out by means of the galvanometer the points where extra resistance exists from dirty contacts. With ordinary protection from dust, and an occasional cleaning of the sliding contacts, the arrangement will remain in very good order for several months.

I have found in practice that it is highly convenient to retain a standard coil or hank for all the usual sizes of wire, and to replace the hank directly another is met with of superior conductivity.

The only preparation the wire requires before testing is to pass it through a clean chamois leather before taking its diameter.

When testing wires of larger diameter it is best to use two grooved drums, one to contain the standard, and the other the wire to be tested. Each drum carries a strong brass flange graduated on its periphery into mm., so that a sliding contact divides the wire in the same way as before. In this way the copper conductor used for the Persian Gulf cable was tested. This conductor consisted of a solid wire ·111″ dia.

Diagram No. 2 is the ordinary form of bridge with the divided wire; as the contact slides along this wire it is obvious that its calibration will suffer some change by continued use. A remedy has been proposed to replace the German silver wire originally used in their construction by a harder metal or alloy. The advantages of the form I have here given are—firstly, no friction along the wire is necessary, and the difference in length is at once accurately read off.

It was the practice, and, indeed, I believe even now is sometimes adopted, to insert extra resistance, with a view of swamping, so to speak, the resistance due to contacts, &c. This is objectionable, on the point of principle it is intended to serve, and whilst giving the branches different values of resistance introduces the serious chance of errors from testing.

M M′ is a hard drawn wire (usually of German silver, No. 16, B.W.G.), a metre in length, soldered at its ends to the stout copper pieces M′ D and M D′. A boxwood scale divided into M M is arranged parallel to the wire, so that the sliding contact C, which may be moved along it, indicates on the scale the point of electrical division. The battery B has one of its terminals connected by means of a key with the sliding terminal C, and to the central terminal of the block A′ is connected the other terminal of the battery.

R and R′ are the two resistances which are to be measured or compassed. E and E′ are two equal resistances inserted to increase the sensibility of the arrangement. A A′ and A″ are three pieces of copper insulated from each other, and supplied each with three terminals, to which the galvanometer and coils are attached as shown.

The resistances R and R′ are to one another, when equilibrium is obtained, inversely as the opposite and corresponding numbers of M M contained between M′ C and M C. As the stretched wire M′ M, by the action of the sliding contact C, becomes unequal in its diameter after being in use for some time, the resistances R and R′ are charged so as to be balanced with the opposite proportion in M′ C and M C, and then the mean is taken as the correct value.

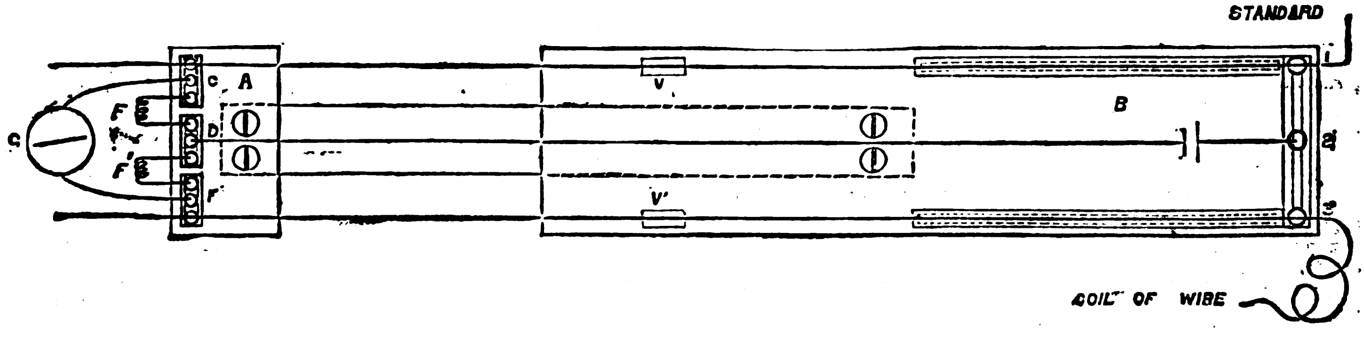
It is obvious that this form of arrangement would be of little use when a great number of wires have to be tested. When the adjustment is complete the wire to be tested against the standard has to be carefully measured off.

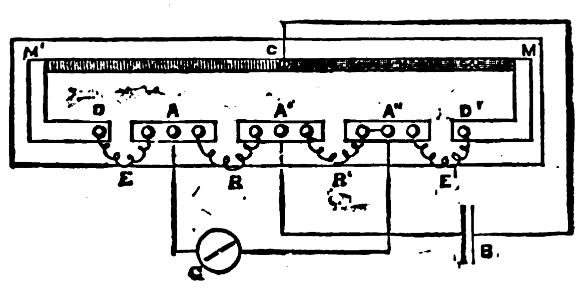
Fig. 3 is taken from a paper read by Sir William Thomson, before the Royal Society, on this subject. In my arrangement the bisected wire of Sir William Thomson is replaced by the standard wire itself, so that all the three branches may be symmetrical in every way. In fact, the form of the bridge which I have here given was adapted from this paper, so as to be practicable for factory use.

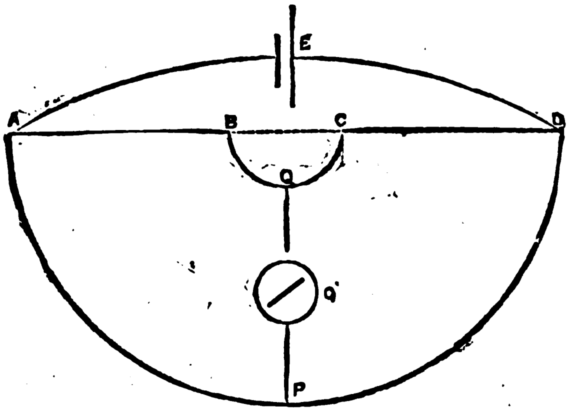
The use of galvanometers of low resistance was to assimilate to this method the suggestions of Mr. Louis Schwendler.*

The form of apparatus which I have here described can be obtained from the India Rubber, Gutta Percha, and Telegraph Works Co., Silvertown.

* Phil. Mag. Vol. 33, p. 30.







Influence of Electricity on Evaporation.—In the *Comptes Rendus* it is stated that Mascart arranged a series of small evaporating basins under conductors, which were kept in a constant electric state by a Holtz machine, moved by water power and placed under a glass case, in which the air was dried by vessels containing sulphuric acid. The experimenter found that the evaporation was constantly increased under the electrized gratings, whether the electricity was positive or negative, evaporation being sometimes doubled.

Australian Telegraph Conference.—A conference of representatives of all the Australian Colonies has been held on the subject of Telegraph Communication between England and Australia. The presence in South Australia of Colonel Glover, the managing director of the Eastern Extension Australasia and China Telegraph Company (Limited), who arrived by the *Chimborazo*, from London, induced the South Australian Government to bring the matter under the notice of the Government of Victoria, and, between the two, the conference was determined upon, and has been held in Melbourne.

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CONTROLLING AND CORRECTING CLOCKS BY ELECTRICITY.

A paper on this subject was read at the Society of Arts on Wednesday evening, 22nd inst., by Frederick J. Ritchie, Esq., of Messrs. J. Ritchie and Son, Edinburgh. He began by describing the system of time signals initiated by Greenwich Observatory, and sent to the principal towns of Great Britain, and noticed a few of the most successful results in the application of electricity to clocks, which might be classified under three divisions :—

1st. Those whose motive power is wholly electric, and which are wholly independent of any other force whatever.

2nd. Those depending on currents of electricity transmitted at regular intervals, and applied directly to carry forward the wheel-work and hands.

These two classes require no periodical winding-up, and may properly be termed electric clocks.

3rd. Those which, being complete clocks in themselves, and capable of performing all the duties of clocks without the external aid of electricity, show their own time, and require winding up at certain intervals, but, for the purpose of being made more useful and correct timekeepers, have currents of electricity transmitted from some standard clock, so applied as to control and correct the vibration of the pendulum or the movements of the wheel-work and hands, and so cause them to show uniformity of time with the governing clock.

Mr. Alexander Bain's electric magnetic pendulum was noticed, and high praise given to Mr. R. L. Jones's method for securing coincident time to the fraction of a second. Mr. Ritchie then described the electro sympathetic clocks introduced by his firm about five years ago, which are in use in many public offices, and have been exhibited at the South Kensington Exhibition of scientific instruments. The attention of the firm has recently been given to means of reproducing the most minute divisions of time, and the rest of the paper was devoted to their experience and success in accomplishing this end, with some indication of what has been done by others in the same field. Thus, about thirty-six years ago, the late Mr. Alexander Bain proposed a method of setting the minute hands of ordinary clocks to correct time every hour in a most simple and effective manner. Whether he ever put his system into actual operation, or to what extent, the lecturer had been unable to learn, but the plan is noticed in a pamphlet published in 1843, "On the Application of the Electric Fluid to the useful Arts," and is, fortunately, illustrated by a diagram and description with references. An electro-magnet was placed behind the dial of the clock to be corrected. The armature of the magnet carried a rod ending in a fork or V immediately above the figure XII. A pin projected back from the minute hand was so placed as to clear the arms of the V when the armature was at rest, or in its normal position, and forced to occupy the angle of the V, when, by the attraction of the magnet, the armature and rod were drawn upwards. Exactly at the last, or sixtieth second of the hour, as shown by the normal clock, contact was automatically made by it with a battery in connection with the line wire, so rendering the magnet active, and attracting the armature, and forcing the V against the pin in the hand, causing it to indicate the exact hour if within its range of action. The simplicity of this application must strike everyone, both from its direct action and fewness of mechanical parts.

To obviate defects found in Mr. Bain's method, Messrs. Ritchie substituted an I or block system, by removing one limb of the V and placing the other at a smaller angle to the pin on the hand, and giving the clock a slightly gaining rate. Instead of a momentary signal or current, one was adopted of fifteen seconds' duration, commencing at the fifty-ninth minute, forty-fifth second of each hour, and ending at the sixtieth second, or the exact hour of the normal clock. An automatic break is used where the line wire is passed by a spring, which is held out of contact with the battery terminal by means of a double lever, one end of which rests on the periphery of a disc upon the same axis as the minute hand. A notch in this disc allows the descent of the lever for a portion of a minute once an hour, during which the second lever comes into action on a disc on the scape wheel arbor. This has a step cut away for one-fourth revolution to allow the lever to fall and contact to be made by the spring on the stud, commencing at the forty-fifth and ending at the sixtieth second, during which time a current is passed to the line.

The adoption of this system at once enabled Messrs. Ritchie to reduce the battery power, and to secure the hand more firmly to the clockwork, so that larger clocks could be placed in circuit and treated with safety. Further experience led to other slight modifications, and for the system is now claimed the following advantages over any previous methods of correction :—

1st. Extreme simplicity and lightness of the mechanical parts, and anyone conversant with electricity will at once appreciate how much depends on that.

2nd. The battery power required to work it is very small. This is obtained :—

(a) From the amount of motion in the stop pin being so small that the magnetic action on the armature is very powerful.

(b) No mechanical work is demanded of the current in setting the hands of the clock.

(c) No friction appears to be overcome, except that of the axis or centres on which the lever works.

(d) The preponderance of the double lever over the armature is just sufficient to ensure its falling out of action, consequently no power is wasted in doing unnecessary work or lifting useless weight.

The friction which (although it would prove very small) would be caused by the pressure of the scape wheel upon the stop pin is got rid of entirely by taking advantage of the inclined surface, or impulse part of the pallet, to wind back the wheel by the vibration of the pendulum, and allow the lever to fall freely out of action.

3rd. The certainty of action is very great, as the forward motion of the clock is arrested at the last wheel, or the point of greatest leverage in the train, and all uncertainties of elasticity are removed.

4th. The hands may be so securely fixed as that no exposure can affect them without wholly stopping the clock.

By no other method yet suggested could correction be applied to a large steeple clock, as any interference with the hands of such would result in the destruction of the apparatus or breaking the hands.

5th. The range of action is also very great. Should the clock be accidentally set slow of correct time, it will, by its own normal gaining rate, be accelerated till the hands indicate correct time, and only then will any action be performed by the corrector. Should the clock be set fast, even to the extent of five minutes (for the disc is cut to cover that extent of error) then the corrector could, by arresting the wheel work for the whole fifteen seconds in each hour, gradually eliminate the error, and have the clock set automatically to coincident time with the normal clock, and then resume its correcting action.

6th. It is applicable to clocks of all qualities and sizes, from the commonest German or American kitchen clock to the largest clock ever constructed, or which could be made or even conceived.

7th. The smallest possible expense in furnishing and fitting of apparatus and maintainance of battery power.

CORRESPONDENCE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Now that so much is done to add to the general welfare of members of the various classes and professions at home and abroad, it cannot be amiss to draw attention to the desolate state of the electrician or telegraph operator on a foreign cable station. It is well known that persons thus occupied lead as uncertain and frequently as comfortless a life as can be found in the civilized or uncivilized world. This, I think, is caused partly by the necessity of their position, and partly by the ignorance, thoughtlessness, or indifference of those who are placed in authority over them. As far as I know, there is no care taken, in the first place, to select intelligent and well-conducted men for the appointments, and, in the second place, to give men fair opportunities to continue well-conducted, or to grow in intelligence. Surely, directors might try to secure healthy quarters, pleasantly furnished, and supplied, moreover, with a good library. They might also give every facility for the procuring of wholesome and well-cooked meat and drink. Some of these may appear, at first sight, to be very small matters; but they all belong closely to the moral, mental, and physical well-being of the class, and by taking some such steps as we have suggested, and lastly, but not least, by interesting the Consuls, Clergy, and others in the staff of the Cable Company, directors and chief officials would raise greatly the reputation and social *status* of the calling, and their good deeds would inevitably bear fruit in a harvest of "good times" for their company.

E. A.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: A preliminary specimen number of *The Electrician* having come under my notice, I hasten to congratulate you on the enterprise. Seeing that you invite suggestions, and are prepared to act in accordance with the general desire of your readers, I am tempted to suggest, as a suitable topic for the "Students' Pages," a series of papers on the manipulation of tools, more particularly as applied to the manufacture of electrical instruments.

The study of electricity requires manual dexterity in the workshop, in order to practically apply the theories mentally conceived, and I think that practical directions in the management of tools would prove very acceptable to those striving to perfect their knowledge.

It is only by an appeal through your columns that it is possible to ascertain how far this topic interests the general readers, and I, therefore, adopt this means of bringing the subject before them.

Wishing *The Electrician* every success, faithfully yours,

MERELY DEXTER.

LITERATURE.

Pocket-Book of Useful Formulæ and Memoranda for Civil and Mechanical Engineers. 19th Edition. By Guildford L. Molesworth. E. and F. N. Spon. —This book is so well known and of such acknowledged worth, that we should have little to say, except to notice the issue of a new edition, if a section relating to telegraph construction had not been added to the work, thus bringing it more under our special domain. Mr. R. L. Brough and Dr. Paget Higgs have compiled fifty pages of valuable formulæ and tables, all the more valuable from the thorough knowledge these gentlemen have of what is useful in practical telegraphy. It is exceedingly difficult with a large number of formulæ, to decide what shall be given and what must be left out, but our authors have been fairly successful in choosing such formulæ as are of the greatest practical importance. Although the book, as a whole, is specially adapted for engineers, it will be found useful to almost all students of physical science. The memory should not be too

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heavily weighted, and such aids as are given here cannot be despised, inasmuch as the knowledge that the matter is reliable will free the mind from doubts as to whether a formula is correctly remembered. We do not for a moment suggest that it is sufficient to have a book of this kind and to place a blind reliance upon its statements. The person who uses it should know the principles upon which the formulæ are based and be able, as occasion requires, to modify any particular one.

The Illustrated Paris Universal Exhibition. Office of the *Illustrated London News*.—We have received the third number of this publication, which is the English edition of *l'Exposition Universelle de* 1878 *Illustrée*, a sort of periodical handbook of the great show at Paris. Besides some good illustrations, it contains articles on the various departments and features of the exhibition. Electricity occupies a prominent place in the present number, where, under the head of "Scientific Inventions," we have an article on Developments of the Telephone.

STUDENTS' COLUMN.

A series of papers specially written for students is in preparation, and will be commenced in an early number. Meanwhile we trust readers will ask for any information they may require relating to electrical studies, and that they will endeavour to aid one another by answering questions proposed in this column.

1. Suppose I wish to replace one conductor by another of (1) the same, (2) of different material; but the resistance is to remain invariable. How can I ascertain the length required?

α. Give the general equation.

β. What length of Cu wire, 4·5 mm. dia., is equivalent to 120 yards 1·5 mm. diameter?

γ. Given that the conductivity of Cu = 1
" " " Fe = ·138
How thick must an iron wire be which for the same length offers the same resistance as a Cu wire 2·5 mm. diameter?

John Savait.

2. How am I to find the *quantity* of electricity generated in a secondary by a primary equal in all respects to the secondary? C. Lee.

3. What is the Wheatstone's Bridge Method in duplex telegraphy?
C. Lee.

4. Two wires, having respectively resistances of 75 and 125 ohms, are joined at the ends.
Find the joint resistance and the current in each wire, the total current being 25 farads?

5. *Electrolysis of Water*.—You cannot decompose water in a Voltameter by a single cell composed of platinum and zinc in acidulated water. Show why, in accordance with the mechanical theory of heat, this decomposition is impossible?—*G.*

6. *Electrical Induction*.—Lay the resinous cake of an electrophorous in a metal form. Excite the cake negatively by brisk friction with flannel or a fox's brush. Lift the cake, the under surface is found negatively electrified; restore it to its form, and let it remain there for some hours; on lifting it again, its under surface is found positively electrified. Explain those observations, and illustrate the subject further if you can.

Guillaume.

RECENT PATENTS.

2538. Electric Telegraphs, *J. and A. Muirhead.—Dated July* 2, 1877. 10*d.*

This consists in employing an inductive resistance to form the differential sending circuits for duplex working in lieu of the combination of ordinary condensers with a bridge or resistance coils. The apparatus for obtaining the inductive resistance consists of two plates of metal separated by a di-electric, one plate having a single connection, the other having two, and being divided into a continuous strip.

2585. Lamps, &c., for Electric Light, *W. Prosser and W. E. Moore.—Dated July* 5, 1877. 6*d.*

This consists in mounting the electrodes in carriers, to which either a continuous or intermittent motion is given by any suitable gearing, the speed being so regulated to the rate of combustion that the focus of the light will not be affected thereby. The electrodes may be in the form of a stick, to which a vertical motion is given, or they may consist of serrated discs, to which a circular motion is given, the electric current being confined to the teeth in juxtaposition.

2693. Telegraph Appartus, *L. Carlander.—Dated July* 12, 1877. (*Not proceeded with.*) 2*d.*

The system consists of a perforator and transmitter. The former consists of knobs connected with levers which operate the punches producing the writing. The transmitter consists of two arms drawn towards contact studs in metal discs by means of springs. The arms are in connection with the poles of the battery, and the studs are in connection with line and with earth.

2720. Synchronising or Setting Clocks, *G. Lund.—Dated July* 16, 1877. 6*d.*

This consists of improvements on patent No. 3924, dated October 11, 1874, and is constructed as follows:—A pair of levers are pivoted to a horizontal stud, and one arm of each acts upon the set hand of the clock, the other arm of each being inclined and crossing each other. A weighted lever held by a catch carries a pin entering the space between the crossed arms of the levers. An electric current releases the weighted lever every hour, thus causing it to drop, and by acting on the crossed arms causes the shorter arms to act on a projection on the set hand, and consequently bring the minute hand to zero. A cam on the set hand lifts the weighted lever back into the catch.

3139. Receiving Instruments of Electric Telegraphs, *J. and A. Muirhead.—Dated August* 17, 1877. 6*d.*

This is essentially an improved siphon recorder, the improvement existing in the maintainance of the ink flow. A fine platinum wire is inserted in the glass siphon, dipping at one end into the ink, and terminating near to the point of the Siphon facing the paper. The ink reservoir and paper-roller are connected to the secondary terminals of a Rhumkorff's coil, and a continuous discharge of electricity takes place between the paper and the platinum point, which drives the ink before it.

3487. Electric Telegraph Apparatus, *L. A. Brasseur and S. W. M. de Lussex.—Dated September* 15. (*Not proceeded with.*) 4*d.*

In place of the spring of the ordinary Morse instrument, two soft iron cores are placed near the ends and on opposite sides of the armature. The opposite ends of these cores are coupled by a permanent horse-shoe magnet. This magnet, acting through the soft iron cores, attracts the armature, and holds it away from the electro-magnet. The line currents are caused to pass through all the coils.

3549. Telephone, *T. W. Mann.—Dated September* 21. (*Not proceeded with.*) 2*d.*

The apparatus consists of a reverberatory or sounding arrangement fixed at each end of a conductor. The sounding arrangement preferred is a lens or stretched membrane of some thin organic material stretched on a sounding board or drum.

3552. Constructing and Arranging Magneto-Electric Apparatus, *A. S. Hickley.—Dated September* 21. 6*d.*

To each pole of a permanent magnet, mounted suitably and insulated if necessary, is attached one end of a small bar of soft iron, the other end having attached thereto a vertical rod of the same metal, which acts as a core to a coil of covered wire, through the centre of which it passes and projects slightly. A bar of soft iron resting on the tops of the rods forms an armature. This armature can be raised as required, and thus the cores polarized and a current generated in the coils, which current can be utilized.

2463. Relays for Electric Telegraphs, *C. H. G. Risch.—Dated June* 26, 1877. 6*d.*

This consists in a relay tongue or tongues having the form of a circle, or segment of a circle, mounted at their centres so that they can turn freely thereon, and which are presented towards poles of electro magnets having coils connected to the line, so arranged that without the aid of lateral springs the tongues maintain a middle position, and are deflected to right or left by electric impulses transmitted by the line.

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THE ELECTRICIAN.

The want of a weekly paper devoted to the consideration of Electrical subjects has long been felt, and we venture to attempt to supply the want. The following gentlemen, among others, have promised their aid:—

Adams, Prof. W. G., F.R.S.
Anderson, Sir James.
Andrews, W. S., M.S.T.E.
Clark, Latimer, C.E., M.S.T.E.
Cumming, L., M.A.
Dewar, Prof. J., F.R.S.
Edison, Thos. A., M.S.T.E.
Ferguson, Prof. R. M., M.A.
Forde, H. C., M.I.C.E.
Foster, A. le Neve, M.S.T.E.
Garnet, W., M.A.
Guthrie, Prof. F., F.R.S.
Higgins, F., M.S.T.E.
Hockin, C., M.A., C.E.
Hughes, Prof. D.E., M.S.T.E.
Jamieson, A., M.S.T.E.
Jenkin, Prof. Fleming, F.R.S.
Langdon, W., M.S.T.E.
Lodge, O., D.Sc.
Mills, Prof. E.J., D.Sc., F.R.S.
Moncel, Count Theodor du.
Muirhead, A., D.Sc., F.C.S.
Prescott, G. B., M.S.T.E.
Richards, Admiral Sir Geo., C.B., F.R.S.
Routledge, R., B.Sc.
Sabine, R., C.E.
Schwendler, L., M.S.T.E.
Smith, G., B.Sc.
Smith, Willoughby, M.S.T.E.
Spagnoletti, C., M.S.T.E.
Sprague, T. J., M.S.T.E.
Stewart, Prof. Balfour, F.R.S.
Thompson, Prof. Sylvanus P., D.Sc.
Thomson, Prof. Sir William, F.R.S.
Thomson, J. M., F.C.S.
Tomlinson, H., B.A.
Tribe, A., F.C.S.
Warren, Thos. T. P. Bruce, M.S.T.E.
Whipple, G. M., D.Sc.
Wormell, R., M.A., D.Sc.
Wilson, W. J., F.C.S.

We shall be glad to receive suggestions from those who are interested in the work, as we desire to meet the wants of readers, and not to carry out rigidly any preconceived ideas of our own. All suggestions will receive careful attention. As a rule, each number of *The Electrician* will contain:—

Notes on electrical and cognate subjects.

Articles of a technical nature.

Articles of a more general character, on subjects bearing directly or indirectly on telegraphic progress. We hope to make this portion of each issue interesting and important to shareholders, and shall keep their interests steadily in view.

Translations and extracts to keep readers *au courant* with the work of the Continent and of America.

Correspondence of a general character, corresponding to the articles of similar nature.

Correspondence of a special and technical nature. Under this head we invite students to send questions on electrical subjects, to be answered by their fellow-readers.

Students' Pages. These pages will be specially written for students, keeping constantly in view that they are not perfect in their knowledge, and do not despise information upon topics which may to others seem worn threadbare.

Reviews of Books. It is a mistake for a student or scientist to be too parsimonious in the matter of literature. There can be no doubt that a good library is a most valuable acquisition. We shall endeavour to give an unbiassed opinion as to the merits or demerits of any work submitted to us by author or publisher.

Reports of Meetings, of Scientific Societies, and of Telegraph Companies.

Abstracts of recent Patents.

NOTES.

Perfecting of the Telephone.—At a recent meeting of the *Académie de Sciences*, a letter was read from the French Consul at Milan, announcing that M. Ridi of Bologna had just succeeded in giving to the telephone a power hitherto unknown, which would allow more than a hundred persons to hear at once speech, singing, or instrumental music. It was not stated what was the arrangement that affords such results, but the inventor had started for Paris.

Antimony v. Carbon.—In a letter to the *Journal of the Society of Arts*, Mr. R. J. Nunn advises electricians to use antimony as a negative element to replace carbon in some galvanic batteries, especially those in which sulphuric acid or chromic acid is employed as the exciting fluid. He says he has used this metal for about five years in some batteries employed for medical purposes with satisfactory results. He claims as its advantages its cheapness; the absence of sealing or disintegration; that the broken plates retain their commercial value, and may be melted up and recast; also, that action begins immediately upon immersion, whilst he states as a disadvantage its brittleness when formed into thin plates, which may be overcome by casting on a core of tougher metal, or alloying with a very small percentage of some other metal.

Popular Science.—The million look not to strictly scientific literature in order to obtain a smattering knowledge of scientific progress, but to the more popular monthlies. It is a remarkable fact that the periodicals are regularly producing a certain amount of scientific information, and thus cultivating the popular taste to that point where it can be made to comprehend the "reign of law." We notice that the June number of *Good Words* contains a paper on "Telegraph Construction in the Forest Primeval." This paper refers to the introduction of the telegraph into the Argentine Republic and into New Zealand, and barely mentions Persia and Africa, but enough is said to show that pioneers, here as elsewhere, have no easy task. Of course the paper is not strictly scientific, but in interesting readers it may raise a desire to know a little more about telegraphs, and foster a taste for serious scientific studies.

Electricity and Biological Experiment.—In order to make these notes and abstracts complete, we intend to notice every paper on electrical subjects which comes before us, otherwise we should not refer to the researches of J. Burdon Saunderson, F.R.S., and F. J. M. Page, F.C.S. These gentlemen presented a paper to the Royal Society at its last meeting on "Experimental Results relating to the Rhythmical and Excitatory Motions of the Ventricles of the Heart of the Frog, and of the Electrical Phenomena which accompany them." Researches of this character *may* prove beneficial hereafter, but unless the experimentalist can show that he has a direct object, and not merely a desire to advance science, we should hesitate before giving a positive countenance to such work. For the results of the experiments described in this paper we must refer our readers to the abstract which will appear in the forthcoming number of the "Proceedings of the Royal Society."

An Automatic Railway Signal apparatus has been invented by a Swede, and, it is said, enables the station officials to know the precise position of any train at any time; it gives sound-signals to the engineer, and at the station before the train enters, thus enabling switches to be cleared and arranged in time to prevent accident. If two trains approach each other, whether running in the same or in opposite directions, the engineers of both trains receive

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signals in time to prevent collision, and the station people are at the same time automatically informed of the position of both trains. Any train may, by stopping at certain points of the road where "contacts" are arranged, open telegraphic communication with the stations at both ends of the route, and two trains may in the same manner telegraph to each other.

Edison at Home.—The New York *Daily Graphic* has been "interviewing" Mr. Edison at Menlo Park, which might be called Edisonia, since at present it consists of nothing but his workshops and half a dozen houses inhabited by his *employés*, though what it may be destined to become is possibly beyond the imagination even of an American editor. The great inventor, who seems to have submitted meekly to the inevitable reporter, is described as a thin, tall man of no more than thirty-one, with the characteristic features of an American, the nasal accent of a "down-easter," and the slovenliness to be expected in a genius who, unlike some other geniuses, works eighteen hours out of the twenty-four, and when in the fever-fit of discovery or research will not go to bed for days together, but sits among his apparatus or surrounded by a perfect mountain of books, swallowing a little food as he works and snatching some sleep in his chair. To perfect one invention two thousand experiments had to be carried out. For the satisfaction of the reporter he asked one of his clerks how many patents he had taken out, and was told one hundred and fifty-seven, besides seventy-seven then being proceeded with at Washington. Most of these are, of course, of no real value, but intended as a precaution against the sharks who are always ready to rob a discoverer of the fruit of his ideas. Mr. Edison's life is evidently a more useful than comfortable one.

Progress of the Electric Light.—The Cleveland (Ohio) *Herald* lately witnessed a trial of the electric light at the establishment of the Union Steel Screw Company, in that city. The apparatus used has been constructed for the illumination of a large carpet mill in Philadelphia. It consists of a Brush dynamo-electric machine of 12,000 candle power, arranged to give four separate currents, each running an electric lamp of 3,000 candle power. Two of the lamps were placed on the third floor and two on the fourth floor of the immense building, and, when the engine was started up, the machine started at the same time, and, without the slightest manual interference, the lamps flashed out their light in all its magnificence. The effect was most brilliant. The rooms were flooded with a pure white light like the light of the sun, and it streamed out at all the windows, illuminating houses and streets for a long distance in every direction. The light was very uniform and steady, free from the flickering that used to be an accompaniment of electric light, and, considering the enormous illuminating power, it was unexpectedly soft and endurable to the eyes. An opportunity was afforded to test the character and whiteness of the light. Worsteds, scarfs, afghans, &c., of brilliant shades, were hanging against the wall at one side of the room, and it was noticed that the colours were brought out as clearly as by the full light of the sun. Estimates were made as to the amount that the light furnished by this apparatus would cost, if used by the Screw Company as it was used on this occasion, and it was ascertained that the total cost of the whole light from the four lamps, including the items of consumption of carbon in the lamps, interest on the investment, and wear and tear, would not exceed thirty cents an hour. The light produced was photometrically equal to 800 gas burners burning five feet of gas per hour each. This amount of gas would cost about 32*s.* per hour.

On the Photometry of the Magneto-Electric Light.—In a paper read before the Royal Society, Captain Abney states that for the last three years he has been investigating the illuminating power of various lights submitted to the Government as suitable for military purposes. The first comparisons were made by the method of extinction, that is, by the introduction of a screen graduated in opacity between the eye and the light. The great defect in this method is the variation in the sensitiveness of the eye. Later, Captain Abney endeavoured to compare the values of the different coloured components radiated from the source of light, with the aid of an apparatus consisting of a double spectroscopic arrangement, which so admitted the light that the spectra appeared to the eye vertically one over the other. After screening off all of the two spectra except a narrow strip, and by applying a telescope with a divided lens, which was described, the intensities of the two strips were equalised by widening or narrowing one or other of the slits. The ratio of the widths of the slits gave approximately the values of the different intensities of the light in the particular part of the spectrum. For light giving a continuous spectrum the method answered admirably. This method was then abandoned, and another was sought which should integrate two or three parts of the visible spectrum. Captain Abney found Bunsen's method of photometry uncertain. The primary object of these experiments was to ascertain the relation between the horse-power employed and the number of revolutions of the armature. The machine employed was of the Gramme form, and weighed about 17 cwt. It had three pairs of vertical coils, one of which was used for magnetization. To work it a locomotive, known as a steam sapper, was used. In addition to the optical readings, an endeavour was made to secure a record of the actinic value of light. Paper sensitised with silver chloride was exposed to the light at a distance of three feet from the carbon points, one strip was placed behind a cell filled with quinine sulphate, whilst another was exposed to the full action of the unshaded light. The times of exposure varied between one and ten minutes. The intensity of the actinism was measured by Roscoe's method, which need not be described. An elaborate series of tables and curves illustrate the results of the experiments. The electrical conditions of the circuit were:—

The resistance of the stationary wire = 4·46 ohms.
" " magnetizing coil = 0·44 ohm.

In the generator the resistance of the light circuit coil = 0·24 ohm. The light coils were in divided circuit, as were also the right and left stationary coils. When driven at from 375 to 383 revolutions the resistance of the voltaic arc was about 0·18 ohm.; the other resistances in the circuit were 0·7 ohm. The E.M.F. of the machine when driven at the above speed was 111 volts, a measure which has been arrived at by Captain Armstrong from other experiments. The E.M.F. between 375 and 383 revolutions of the armature was assumed to vary as the number of revolutions, an assumption which was borne out as practically correct by other measurements made for the purpose. It is noticed that practically the electro-motive force increases directly as the number of revolutions of the armature, a result which might have been expected theoretically. The current, also, for any given number of revolutions, varies inversely as the resistance in circuit, or, in other words, the E. M. F. for a given number of revolutions is constant. In any results which may be given descriptive of the light produced by any machine, the following points should be noticed:—*(i.)* Number of revolutions of armature; *(ii.)* Resistance in circuit; *(iii.)* Horse-power expended; *(iv.)* Colour of light measured; *(v.)* Electro-motive forces; and *(vi.)* the size of the carbons employed.

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DYNAMO-ELECTRIC MACHINES.*

The managers of the Franklin Institute having empowered the committee to purchase a dynamo-electric machine, it was deemed advisable to test various machines before making the purchase. Sub-committees were formed for the purpose of making (1) photometric measurements, (2) electric measurements, and (3) dynamical measurements. The machines tried were the Gramme, the Brush, and the Wallace-Farmer machines. The source of power for the experiments was an upright steam engine, 6in. bore of cylinder, 8in. stroke, with a heavy fly-wheel 30in. in diameter, and governors so adjusted as to give speed from 100 to 250 revolutions per minute. The Wallace machine, however, required more power, and was driven by an engine of 9in. bore and 18in. stroke, and the amount of "power consumed" determined from the indicator diagram.

The following is a description of the machines submitted to examination. Their dimensions are given in Table 1:—

The Gramme machine, Fig. 1, consists of two cylindrical electro-magnets, with their combined poles extended by pieces of such shape as nearly to envelop the armature which rotates between them, Figs. 2 and 3. The armature is composed of a ring of soft iron, with insulated copper wire wound over its entire surface. This wire is divided into sixty coils connected successively at their ends, and the loops thus formed between each pair of coils are connected to the copper strips of the commutator. Fig. 2 represents the mode of winding this wire on the ring, only a few turns, however, being shown.

The commutator consists of copper strips equal in number to the armature coils, placed radially edgewise around the shaft of the machine, and insulated from each other and the shaft, thus forming a cylinder the surface of which is composed of alternate strips of copper and insulating material. Upon the surface of the commutator rest bundles of soft iron wire, by which the currents generated in the armature coils are conducted to the external circuit. As the armature is rotated between the poles of the field magnets, currents of electricity are generated.

These machines are also constructed with two commutators, each connected respectively to alternate armature coils, in which case the external circuit can be divided; but it is usual to pass both currents through the field coils, and then join them in the external circuit. This machine runs smoothly and very quietly, with few or no sparks at the commutator, and very little heating, the temperature of the armature being about 93° Fahr. after running nearly five hours.

FIG. I

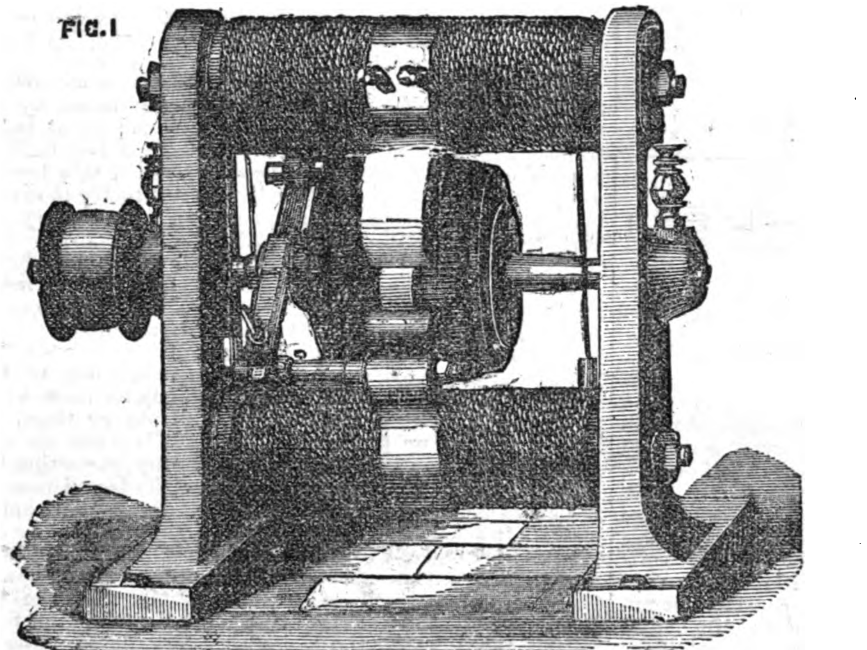


FIG. 2

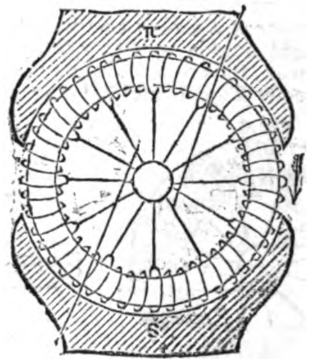
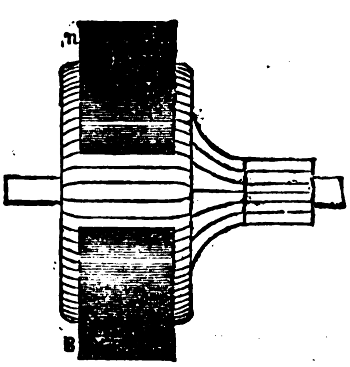


FIG. 3



The Brush machine has, for its magnetic field, two horse-shoe electro-magnets, with their like poles facing each other, at a suitable distance apart, the circular armature rotating between them.

In this machine the currents are generated in coils of copper wire, wound upon an iron ring, constituting the armature. This ring is not entirely covered by the coils, as in the Gramme armature, but the alternate uncovered spaces between the coils are almost completely filled by iron extensions from the ring, thus exposing large surfaces of the armature ring for the dissipation of heat, due to its constantly changing magnetism, as in the Pacinotti machine.

The ring revolves between the poles of two large field magnets, the two positive poles of which are at the same extremity of the diameter of the armature, and the two negative poles at the opposite extremity, each pair constituting practically extended poles of opposite character.

The coils on the armature ring are eight in number, opposite ones being connected end to end, and the terminals carried out to the commutator. Figs. 4 and 5 show this arrangement, only one pair of coils, however, being shown in Fig. 5 as connected. In order to place the commutator in a convenient position, the terminal wires are carried through the centre of the shaft, to a point outside the bearings.

The commutators are so arranged, that, at any instant, three pairs of coils are interposed in the circuit of the machine, work-

FIG. 4

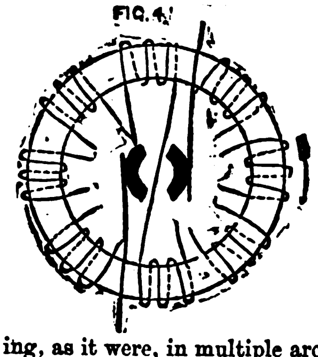
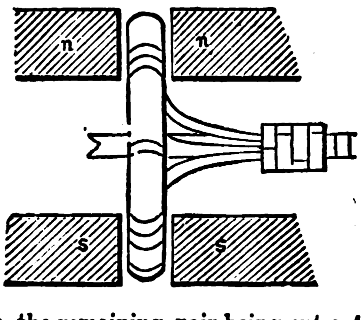


FIG. 5



ing, as it were, in multiple arc, the remaining pair being cut out at the neutral point; while in the Gramme machine, the numerous armature coils being connected end to end throughout, and connections being made to the metal strips composing the commutator, two sets of coils in multiple arc are at one time interposed in the circuit, each set constituting one-half of the coils on the armature.

The commutator consists of segments of brass, secured to a ring of non-conducting material, carried on the shaft. These segments are divided into two thicknesses, the inner being per-

* Report to the Franklin Institute of Messrs. Briggs, Professors Rogers and Chase (Photometry), Professors Houston and Thomson (Elect. Meas.), and Messrs. Jones, Sartain, and Knight (Dynamical Meas.).

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manently secured to the non-conducting material, and the outer ones, which take all the wear, are fastened to the inner in such a manner that they can be easily removed when required.

The commutator brushes, which are comprised of strips of hard brass, joined together at their outer ends, are inexpensive and easily renewed. The high speed at which these machines are run, together with the form of the armature, cause the rotation of the latter to be considerably resisted by the air, and producing a humming sound, but otherwise they run smoothly; the heating of the armature being inconsiderable, not exceeding 120° Fahr. after four and three-quarter hours' run. They are simple in construction, all the working parts being easily accessible, and the cost of maintenance low.

In the larger Brush machines there are two commutators, each of which is connected with alternate armature coils.

By this arrangement connections can be so made as to produce electric currents of high or low electro-motive force (55 to 120 volts, as will hereafter be shown), or the conductor can be divided into two circuits, each of which can be utilised for producing its own light, or for performing other work.

In the Wallace-Farmer machine the magnetic field is also produced by two horseshoe electro-magnets, but with poles of opposite character facing each other. Between the arms of the magnets, and passing through the uprights supporting them, is the shaft, carrying at its centre the rotating armature.

This consists of a disc of cast iron, near the periphery of which, and at right angles to either face, are iron cores, wound with insulated wire, thus constituting a double series of coils. These armature coils Figs. 6 and 7, being connected end to end, the

FIG. 6

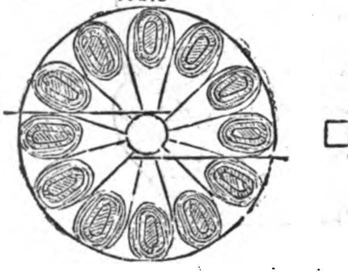
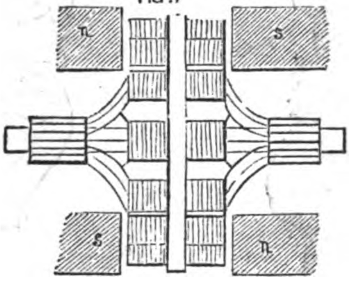


FIG. 7



loops so formed are connected in the same manner, and to a commutator of the same construction, as that of the Gramme. As the armature rotates, the cores pass between the opposed north and south poles of the field magnets, and the current generated depends on the change of polarity of the cores. It will be seen that this constitutes a double machine, each series of coils, with its commutator, being capable of use quite independently of the other; but in practice the electrical connections are so made that the currents generated in the two series of armature coils pass through the field-magnet coils, and are joined in one external circuit. This form of armature also presents considerable uncovered surface of iron to the cooling effect of the air, but its external form, in its fan-like action on the air, like that of the Brush, presents considerable resistance to rotation. In the Wallace-Farmer machine there was considerable heating of the armature, the temperature being sufficiently high to melt sealing wax.

[TO BE CONTINUED.]

PROFESSOR CLERK MAXWELL ON THE TELEPHONE.

Professor CLERK MAXWELL, F.R.S., of the Chair of Experimental Physics at Cambridge, as the Sir Robert Rede Lecturer for this year, delivered a lecture on the Telephone, at the Senate House, on Friday, May 24, in the presence of a large number of leading members of the University and visitors.

Professor MAXWELL said: Mr. Vice Chancellor, Ladies and Gentlemen—When about two years ago news came from the other side of the Atlantic that a method had been invented of transmitting, by means of electricity, the articulate sounds of the human voice, so as to be heard hundreds of miles away from the speaker, those of us who had reason to believe that the report had some foundation in fact began to exercise our imaginations in picturing some triumph of constructive skill—something as far surpassing Sir William Thomson's siphon recorder in delicacy and intricacy as that is beyond a common bell-pull. When at last this little instrument (the telephone) appeared, consisting, as it does, of parts every one of which is familiar to us, and capable of being put together by an amateur, the disappointment arising from its humble appearance was only partially relieved on finding that it was really able to talk. But, perhaps, the telephone, though simple in respect of its material and construction, may involve some recondite physical principle the study of which might worthily occupy an hour's time of an academic audience. I can only say that I have not yet met any one acquainted with the first elements of electricity who has experienced the slightest difficulty in understanding the physical process involved in the action of the telephone. I may even go further, and say that I have never seen a printed article on the subject, even in the columns of a newspaper, which showed a sufficient amount of misapprehension to make it worth preserving—a proof that among scientific subjects the telephone possesses a very exceptional degree of lucidity. However, if the telephone has something to say for himself, it would seem hardly necessary for me to take up your time with any tedious introduction. It is unfortunate, however, that up to the present time the telephone has kept all his more perfect utterances to be whispered into the ear of a single listener. When he is older he may get more accustomed to public speaking, but if we force him, in his present immature state, to exert his voice beyond what is good for him, it may sound rather too like the pot quarrelling with the kettle, and may call for the criticism with which Mr. Tennyson's Princess complimented the disguised Prince on his song of the swallow:—

> "Not for thee," she said,
> "O Bulbul, any rose of Gulistan
> Shall burst her veil; marsh divers, rather, maid,
> Shall croak thee sister, or the meadow crake
> Grate her marsh kindred in the grass."

Is it for this, then, that we are to forsake the luncheons and lawn tennis and all the engrossing studies of the May Term, and to assemble in this solemn hall, where the very air seems thick with the accumulation of unsolved problems, or else redolent of the graces of innumerable congregations. It is not by concentrating our minds on any problem, however important, but rather by encouraging them to expand that we shall best fulfil the intention of Sir Robert Rede when he founded this lecture. It would be as useless as it would be tedious to try to explain the various parts of this small instrument to persons in every different part of the Senate House. I shall therefore consider the telephone as a material symbol of the widely separated departments of human knowledge the cultivation of which has led, by as many converging paths, to the invention of this instrument by Professor Graham Bell. For, whatever may be said about the importance of aiming at depth rather than width in our studies, and however strong the demand of the present age may be for specialities, there will always be work, not only for those who build up particular sciences and write monographs on them, but for those who open up such communications between the different groups of builders as will facilitate a healthy interaction between them. And in a University we are specially bound to recognise not only the unity of science itself but the communion of the workers in science. We are too apt to suppose that we are congregated here merely to be within reach of certain appliances of study, such as museums and laboratories, libraries and lecturers, so that each of us may study what he prefers. I suppose that when the bees crowd round the flowers it is for the sake of the honey that they do so, never thinking that it is the dust which they are carrying from flower to flower which is to render possible a more splendid array of flowers and a busier crowd of bees in the years to come. We cannot, therefore, do better than improve the shining hour in helping forward the cross-fertilisation of the sciences. Before we go further I wish to express my obligations to Mr. Garnett for the able assistance he has given me. He has not only collected the apparatus before you, but constructed some of it himself. But for him I might have given you some second-hand information about telephones. He has made it possible for you to hear something yourselves. I have also to thank Mr. Gower, who has brought his telephone harp, and Mr. Middleton, who has contributed several instruments of his own invention. We shall begin with the telephone in its most obvious aspect, as an instrument depending on certain physical principles. The apparatus (telephone) consists of two instruments, the transmitter and receiver, doubly connected by a circuit capable of conducting electricity. The speaker talks to the transmitter at one end of the line, and at the other end of the line the hearer puts his ear to the receiver and hears what the speaker says. The process in its two extreme stages is so exactly similar to the old-fashioned methods of speaking and hearing that no preparatory practice is required on the part of either operator. We must not, however, fall into the error of confounding the principle of the electric telephone with that of other contrivances for increasing the distance at which a connversation may be carried on. In all these the principle is the same as in the ordinary transmission of sound through the air. The different portions of matter which intervene between the speaker and the hearer (in India-rubber cord) take part in succession in a certain mechanical process. Each receives a certain motion from the portion behind it and communicates a precisely

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similar motion to the portion in front of it, in doing which it gives out all the energy it received and is again reduced to rest. The medium which takes part in this process may be the open air, or air confined in a long tube, or some other medium such as a brick wall, as when we hear what goes on in the next house, or a long wooden rod, or a metal wire, or even a stretched string. In all these it is by actual motion of the successive portions of the medium that the message is transmitted. In the electric telephone there is also a medium extending from the one instrument to the other. It is a copper wire, or rather two wires, forming a close circuit. But it is not by any motion of the copper that the message is transmitted. The copper remains at rest, but a variable electric current flows to and fro in the circuit. It is this which distinguishes the electric telephone from the ordinary speaking tube and from the transmission of vibrations along wooden rods by which Sir Charles Wheatstone used to cause musical instruments to sound in a mysterious manner without any visible performer. On the other hand, we have to distinguish the principle of the articulating telephone from that of a great number of electrical contrivances which produce visible or audible signals at a distance. Most of these depend on the alternate transmission and interruption of an electric current. In some part of the circuit a piece of apparatus is introduced corresponding to this instrument (a Morse's key), which is called a key. Whenever two pieces of metal called the contact pieces touch each other the current flows from the one to the other, and so round the circuit. Whenever the contact pieces are separated the current is interrupted, and the effect of this alternation of current and no current may be made to produce signals at any other part of the circuit. In the Morse system of signalling currents of longer and of shorter duration are called dashes and dots respectively, and by combinations of these the symbols of letters are formed. The rate at which these letter currents succeed one another depends on the rate at which the operator can work the key, and may be increased by mechanical methods till the receiving clerk can no longer distinguish the symbols. But the capability of the telegraph wire for transmitting signals is by no means exhausted. As the rapidity of their succession is increased the ear ceases to distinguish them as separate signals, but begins to recognise the impression it receives as that of a musical tone the pitch of which depends on the number of currents in a second. Tuning forks driven by electricity were used by Helmholtz in his researches on the vowel sounds, and the periodically intermittent current which they furnish is now recognised as a most valuable agent in physical and physiological research. The tuning forks are of the most massive construction, and the succession of currents goes on with the most inflexible regularity, so that whenever we have occasion to follow the march of a process which takes place in a short time, such as the vibration of a violin string or the twitch of a living muscle, the tuning fork becomes an appropriate timepiece. Apparatus of this kind, however, the merit of which is its regularity, is quite incapable of adapting itself to the transmission of variable tones such as those of a melody. The first successful attempt to transmit variable tones by electricity was made by Philip Reiss, a teacher in a school at Fredericksdorf, near Homburg. On October 21, 1861, Reiss showed his instrument which he called a telephone to the Physical Society of Frankfort-on-the-Main. He succeeded in transmitting melodies which were distinctly heard throughout the room. The transmitter of Reiss's telephone is essentially a motive and break key of so delicate a construction that the sound-waves in the air are able to work it. The air vibrations set in motion a stretched membrane like a drumhead with a piece of platinum fastened to it. This piece of platinum, when vibrating, strikes against another piece of platinum, and so completes the circuit every time contact is made. At every point of the circuit, there is thus a series of currents corresponding in number to the vibrations of the drumhead, and, by causing them to pass through the coil of an electro-magnet, the armature of the electro-magnet is attracted every time the current passes, and, if the armature is attracted to a resonator of any kind, the succession of tugs will set it in vibration and cause it to emit a sound the pitch of which is the same as that of the note sung into the transmitter at the other end of the line. [Mr. Gower here played the "March of the Men of Harlech" on the telephone harp placed in the Geological Museum. The instrument consists of a set of steel reeds worked by percussion, which make and break contact on the battery circuit, of which the primary wire of an induction coil forms part. The receivers are worked by the secondary current. There were four receivers, one of them Professor Bell's original one, placed in different parts of the Senate House.] If the pitch of a sound were the only quality which we are able to distinguish, the problem of telephony would have received its complete solution in the instrument of Reis. But the human ear is so constructed, and we ourselves are so trained by continual practice, that we recognise distinction in sound of a far more subtle character than that of pitch; and these finer distinctions have become so much more important for the purposes of human intercourse than the musical distinction of pitch, that many persons can detect the slightest variation in the pronunciation of a word who are comparatively indifferent to the variations of a melody. Now, the telephone of Professor Graham Bell is an articulating telephone, which can transmit not only melodies sung to it, but ordinary speech, and that so faithfully that we can often recognise the speaker by his voice as heard through the telephone. How is this effected? It is manifest that, if by any means we can cause the tinned plate of the receiving instrument to vibrate in precisely the same manner as that of the transmitter, the impression on the ear will be exactly the same as if it had been placed at the back of the plate of the transmitter, and the words will be heard as if spoken at the other side of a tinned plate. But this implies an exact correspondence, not only in the number of vibrations, but in the type of each vibration. Now, if the electrical part of the process consisted merely of alternations between current and no current, the receiving instrument could never elicit from it the semblance of articulate speech. If the alternations were sufficiently regular, they would produce a sound of a recognisable pitch, which would be very rough music if the pitch were low, but might be less unendurable if the pitch were high; still, at the best, it would be like playing a violin with a saw instead of a bow. What we want is not a sudden starting and stopping of the current, but a continuous rise and fall of the current corresponding in every gradation and inflexion to the motion of the air agitated by the voice of the speaker. Professor Graham Bell has recounted the many unsuccessful attempts which he made to produce undulating currents instead of mere intermittent ones. He had, of course, to give up altogether the method of making and breaking contact. Every method involving impact of any kind, whether between electric contact pieces or between the sounding parts of the instrument, introduces discontinuity of motion, and therefore precludes a faithful reproduction of speech. In the ultimate form which the telephone in his hands assumed, the electric current is not merely regulated but actually generated by the aerial variations themselves. The electric principle involved in Bell's telephone is that of the induction of electric currents discovered by Faraday in 1831. Faraday's own statement of this principle has been before the scientific world for nearly half a century, but has never been improved upon. Consider, first, a conducting circuit, that is to say, a wire which after any number of convolutions returns into itself. Round such a circuit an electric current may flow, and will flow if there is an electric motive force to drive it. Consider, next, a line of magnetic force, such a line as you see here made visible by sprinkling iron filings on a sheet of paraffin paper. This line, as Faraday also first showed, is a line returning into itself, or, as the mathematicians would say, it is a closed curve. Now, if there are two closed curves in space, they must either embrace one another, so as to be linked together, or they must not embrace each other. If the line of force as well as the circuit were made of wire, and if it embraced the copper circuit, it would be impossible to unlink them without cutting one or other of the wires. But the line of force is more like one of Milton's spirits, which cannot

> "in their liquid texture mortal wound
> Receive, no more than can the fluid air."

Now, if the copper circuit or the lines of force move relatively to each other, then in general some of the lines of force which originally embraced the circuit will cease to embrace it, or else some of those which did not embrace it will become linked with it. For every line of force which ceases to embrace the circuit there is a certain amount of positive electro motive force which, if unopposed, will generate a current in the positive direction, and for every new line which embraces the circuit there is a negative electro motive force causing a negative current. In Bell's telephone the circuit forms a coil round a small core of soft iron fastened to the end of a steel magnet. Now, lines of magnetic force pass more freely through iron than through any other substance. They will go out of their way in order to pass through iron instead of air. Hence a large proportion of the lines of force belonging to the magnet pass through the iron core, and therefore through the coil, even though there is no iron beyond the core, so that they have to complete their circuit through air. But, if another piece of soft iron is placed near the end of the core, it will afford greater facilities for lines which have passed through the core to complete their circuit, and so the lines belonging to the magnet will crowd still closer together to take advantage of an easy passage through the core and the iron beyond it. If, then, the iron is moved nearer to the core, there will be an increase in the number of such lines, and, therefore, a negative current in the circuit. If it is moved away, there will be a diminution in the number of lines and a positive current in the circuit.

[TO BE CONTINUED.]

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SOME OBSERVATIONS UPON THE SOURCES OF ERRORS IN PRACTICAL TELEGRAPHY.

[CONCLUDED.]

BY SIR JAMES ANDERSON.

I have already shewn by illustration that there are many words essentially different in every way, yet identical in telegraphic symbols. Mr. Whitelaw is cognizant of this difficulty, and believes he has almost overcome it. Where these words are used they lead to just so many demands for repetitions. Upon examining the 100,000 word combinations for this troublesome danger, we find the following

EXAMPLES IN ENGLISH.

Affix as per code.	*Very liable to be received.*
Bed or Bog	Bod or Beg
Ford —Foss	Fors —Fosd
Moor —Nook	Noor—Mook
Pond —Pool	Pood
Run —Land	Lan
Weald—Well	Weld

Each of these twelve syllables may be the termination of 363 prefixes, making 4,356 words in the English portion alone for which repetitions must be frequently demanded. As a further illustration of my meaning, if the affix "bed" was received as "beg," which it might easily be, a repetition would be indispensible, or the receiver could not know whether the word should be "bed" or "bog," the affix "beg" not being in the code.

EXAMPLES IN GERMAN.

Affix as per code.	*Very liable to be received.*
Bahn —Baum	Bahm —Baun
Brand —Brunn	Brann —Brund
Buhne —Busen	Busene—Buhn
Grund —Brand	Grand —Brnnd
Hutte —Hatte	Hatte —Hutte

(The word "Hutte" might also be transformed to "Hug," which would confound it with "Hugel.")

Loben—Lohn	Losen—Lobn
Platz —Gratz	Glatz —Pratz

The foregoing fifteen terminations may be prefixed by 269 different syllables, making a total of 4,035 words in the German portion that are unsuitable for telegraphic purposes.

In the case of the two last words of the preceding list, "Platz" and "Gratz," if we assume that "Platz" has been sent, a single dot lost in the transmission, and the word received would be "Glatz," and there would be nothing whatever to guide the receiver in deciding whether the word should be either "Platz" or "Gratz." The question would be whether the "P" or the "R" had been altered, and a repetition would be indispensable.

EXAMPLES IN INDIAN.

The Indian affixes, so far as dissimilarity goes, are decidedly the best, but the limited knowledge English clerks have of Hindostani would always render them liable to mutilation.

Affix as per code.	*Very liable to be received.*
Suluk—Halka	Haluk

("Lu" and "Ha" being similar in telegraphic conformation.)

Galli—Mulk	Galk

("Ga" and "Mu" being similar in telegraphic conformation.)

The above six syllables may terminate 368 different prefixes, making 2,208 more or less objectionable words in the Indian portion.

Thus we have in Mr. Whitelaw's combinations a total of

English words	4,356
German "	4,035
Indian "	2,208
	10,599

or over 10 per cent. of the 100,000 word combinations. So that, with messages averaging twenty words, you provide for the greatest possible probability of having two words in each message for which a repetition would be demanded.

Once fairly admit these combinations as a principle, and it would soon be impossible to prevent German or Indian affixes to English prefixes or syllabic combinations having indirectly a real meaning as suggested by Mr Whitelaw. Even now this is a grievance we have too often to resist.

Affixes in one language and prefixes in another, or any recognised system of affixes and prefixes, would soon be, and in some degree already are adopted for expressing two different classes of transactions, or be used for the telegrams of two separate individuals. For these reasons, amongst others, the plan must be looked upon with suspicion, and the effect upon the earnings of the administrations be seriously considered.

It must be admitted, however, that there are many compound words which are already in use, and that no objection can well be made to them; but it is one thing to accept words of varied length and character by which the administrations obtain the reasonable advantage of a fair average length of words, and altogether a different matter to acknowledge with favour and approval a system which makes every word and every group of figures the maximum length admissible, and affords a unique variety of expansion for combination of a character specially liable to error in transmission.

There is still another disadvantage in compound words, which need only be stated to be appreciated by those who value accuracy in their telegrams as of the first importance. The cause of many errors in telegrams is known amongst us as "guessing errors." The most difficult rule in the service to enforce is to make telegraph operators spell instead of read. This can easily be understood by one's own experience of the facility with which the eye embraces words in reading without recognition of the alphabetical or syllabic construction of the words. From this cause such words as "Abbotfors" might become "Abbotfor;" "Bluebeare," "Bluebeard;" "Blackwatch," "Blackwater;" "Broadgrove," "Broadgreen;" "Childwood," "Childworth;" "Drysbower," "Drysburgh;" "Eastbourn," "Eastbower;" "Foxholme," "Foxhorn," and so on, influenced by the local knowledge or train of thought or other impression on the mind of the operator, or it might be sheer carelessness. I do not claim that we are not to blame for these errors. We fine and do not promote those who are to any extent guilty of them; and our Clearing House system can trace back every error made to the delinquents; but the above, with what has gone before, helps to establish the fact that in practical telegraphy there is much yet to be done to establish accuracy, and, as a consequence, speed. To make any further appreciable advance

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in this direction we are greatly dependent upon the assistance which our customers could afford by their selection of simple code words.

At present it is impossible for administrations to avoid errors altogether. With all the aid of experienced operators, the most perfect recording instrument which science has invented, and constant supervision, we cannot get below an average of about two errors in every hundred messages delivered into the hands of the public, for which a repetition has to be obtained. In addition to this, there are about the same number which are corrected by reference to the company's "guide to corrections," or some other explanation which our superintendents can suggest. Further, from the time a code message is handed in to our station—say, at Bombay—and transits through six other stations to its destination, the aggregate number of corrections made *in the interest of accuracy* averages five in every hundred *words*. In the same general interest, as well as for the protection of the administration, each message necessitates five words in the preamble, for which no charge is made.

Ordinary code language in general use, expresses upon an average six words for every code word paid for. I am aware there are codes in use by some agencies, far exceeding this average.

I have already said that numerals occupy the line quadruple, and simple code language double, the time required for the transmission of ordinary language. All refinements of word combinations must, therefore, increase that evil more especially from the unavoidable number of corrections when the words telegraphically resemble other words, as they must do when it is sought to produce hundreds of thousands of words.

There is still another class of facts not generally understood by the public, which affect the carrying capacity of long submarine cables.

If a cable has a conductor with carrying capacity, say of 20 words per minute, the actual average amount of words sent per minute during a busy day would be about 15, and the money-paying words would be about 10, or one-half the trial speed capacity of the line, and this would be an excellent average for 24 hours with the best operators. This arises from the time lost in taking up, commencing, and ending each message.

We have, then, the capacity of the line and we see it is limited. Submarine cables were formerly specified to have a conductor capable of transmitting so many words per minute. At present the weight of copper and gutta percha per mile is stipulated to secure the same result. These words are the ordinary words of any book or newspaper upon general subjects—not technical—and their average is five letters per word. But, thanks to the code words now in use, the average is at present seven. Once admit combinations as a principle and we see the average would be about ten, reducing the money-earning capacity of such a line to five or six words per minute.

The question of the remedy has now to be considered. The Companies urged upon the Convention the principle of a word-rate, and a single charge for secret or code language, as conditions which seemed to them in accordance with the usage of commerce and calculated to promote the growth of traffic, upon the principle that merchants would send a greater number of telegrams if they only paid for the actual words required to promote the transaction, instead of paying for 10 or 20 words whether they are necessary or not, and it was anticipated that, besides conducing to the growth of traffic, the administrations would get paid for the actual work done.

The result has been a considerable increase in the number of messages with a host of words requiring repetition, and a large reduction in the revenue. That is, we do much more work for less money. Still, no one has yet urged that the principle is unsound. There is still the hope that it is the right base from which to expand. The principle is altogether clear of artificial restrictions, and would be likely to have an enduring existence if the commercial public do not discover a method of combination which shall reduce our revenue to a point which shall compel us to revert to restrictive rules and higher tariffs.

The present demand for elaborate systems of commercial code, has already arrived at expressing for each word a minimum average of four words in any code I have seen, but ranges as high as an average of fifteen words. And upon investigating the effect of these several codes upon our traffic, we find that the greatest number of repetitions are demanded by firms which have the greatest number of words in their code system. I must illustrate what I mean by a little further detail.

The English language has about 16,000 words which are telegraphically suitable for transmitting. French, German, Latin, Hindostani, and Italian have at least 50,000 of a safe telegraphic character, making altogether an aggregate of about 66,000 words which the mercantile community can adopt without resorting to any artificial or fictitious combination, and I venture to think there are few commercial firms whose wants could not be supplied with fewer words than 66,000.

It is a matter of fact that such firms as employ direct simple words, taking care to eliminate those which are too much alike, seldom come to us for a repetition and seldom make any complaint; whereas all firms which have selected cunningly-devised words, besides ringing changes upon the terminations, are frequently demanding repetitions, and our statistics prove that these demands are in proportion to such code words as the firms have in excess of those suitable in the several languages for telegraphic purposes—that is to say, firms using an extended code, with, say, 200,000 words, selected in disregard of telegraphic fitness, really demand from us ten corrections for every one asked for by firms which conduct their business with a code of about 20,000 words compiled with reasonable regard to their fitness for telegraphic transmission, not being too much alike and having a plain meaning.

Any one who has considered the construction of codes will recognise the difficulty of getting so vast a number of words as 200,000 so unlike each other as to secure accuracy.

This, I think, clearly establishes the principle that all code words should be reasonably simple. Great pains, at least, should be taken to eliminate all words which are telegraphically alike. This, besides promoting accuracy, and therefore speed, will encourage all administrations to adopt the word rate and single charge for code or secret language, both of which must be for years after their adoption a clear loss to the revenue of the administration. While fanciful combinations in which the principles I have enunciated are disregarded, must compel all interested in the maintenance of telegraphy to cast about for a defence against the growth of a system in which all the advantages are on the side of the packer, and all the disadvantage to the debit of the telegraph administration.

We are often told that telegraph officials only see it from their own side, and that merchants are convinced they will use the telegraph much more than we imagine if greater *facilities* are given. But all experience ever since the telegraph was established has demonstrated that every *facility* has been at the expense of revenue.

Notwithstanding this fact, we think it is still the duty of those charged with the management of the system to find out if possible the principles which shall have fewest restrictions, and the tariff least likely to retard the development of traffic, and yet support the existence of the communication. These have been the guiding motives at every discussion at the Telegraph Conferences. The profit and loss, the work done and the cost of doing it, the growth under every change of tariff have been well considered and often argued, above all, in the interest of the public. It is only recently that the uniform pecuniary loss of nearly every Government administration has changed the tide of this general advocacy for the exclusive benefit of the public, and it may safely be predicted that every system, which shall be conspicuous for requiring repetitions, and exacting the maximum number of signals as the normal average, will be met with disfavour, and combated in some way or other.

As an individual opinion, I would be in favour of advocating at the next Convention the adoption of an authorised code of 50,000 words selected out of the six languages named, for

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which the single charge would be made, and requiring that the use of any other code words be charged one-and-a-half rates. So far as I can understand secret language and its effect upon commercial transactions and the interest of the companies, we are very near the time when the question must be settled upon a recognized basis, and it appears to me that, with 50,000 words from which to select, all commercial firms other than packing agencies could, within those limits, carry on the general requirements of commerce, and if greater scope is demanded, it might very well be paid for.

In addition to this, it would, I think, be only fair that we should be paid half rates, for all repetitions which are proved to be due to the sender and not to the administrations, or to repetitions which result in no correction whatever. It ought to be urged by us, and I submit remembered by the public, that the occupation of the line needlessly retards the transmission, more or less, of some other telegrams. Repetitions are irritating, they cost the administration a great deal of money and a vast amount of unprofitable and unnecessary work. We cannot, in short, make telegraphy any more perfect unless the public assist us.

THE MICROPHONE.

BY WILLOUGHBY SMITH.

If a small bar or plate of silenium, enclosed in a wooden box, form part of a circuit containing a battery, galvanometer, telephone, and an electric bell, or some other sound-giving instrument, as soon as the lid of the box is raised, and light, either solar or artificial, is allowed to fall on the silenium, immediately the deflection on the galvanometer increases, a sound is heard on the telephone, and the bell rings. Why? Simply because the effect of light on silenium is to lower its resistance, and, by lowering the resistance of the circuit, the electro-motive force of the battery is increased, and thus the result. It may, therefore, with justice, be stated that the fall of a ray of light upon a plate of metal (assuming silenium to be a metal) can be rendered audible, the magnitude of the sound depending upon the power of the battery employed.

Early this month I read in *Nature* that "Professor Hughes had made the wonderful discovery that some bodies are sensitive to sound, as silenium is sensitive to light. If such a body be placed in the circuit of a small battery it will be so affected by the sonorous vibrations when spoken to . . . . a mere scratch with the finger-nail or the soft touch of the finger is distinctly transmitted." I removed the silenium from a circuit similar to the one just described, and replaced it by specimens of every substance which I thought would be likely to give the result stated; but every attempt of mine to produce the effects proved unsuccessful, and I discontinued the experiments in despair. When, however, later on, I read a detailed account, with illustrations, of the experiments which Professor Hughes had made, I at once saw how misleading was the statement I had previously read. There is nothing new in the fact that, if a telephone be placed in circuit with a battery or other generator of electricity, sound will be heard on the telephone each time the circuit is completed or broken, which can be easily done by separating the wire-forming part of the circuit and holding one end in each hand and making or breaking by touching or separating the two ends. The magnitude of the sound on the telephone will of course be in proportion to the magnitude of the power employed, and may be like the fall of a pin or the report of a cannon. Instead of making or breaking the circuit as I have described, what is technically known as a commutator or key may be employed. The beam of a balance which the hundredth part of a grain would turn makes a very sensitive commutator.

It follows as a matter of course that, if any sensitive commutator be placed on a vibrating board or any convenient substitute for the same, the slightest vibration will cause the commutator to oscillate, and thus make or break the circuit, and the intensity of the sound produced depends, as before, upon the amount of battery power employed.

M. Fromont was kind enough to show me, some eighteen years ago, over his workshops in Paris; and in one room, amongst many of the instruments, there was a very sensitive commutator, which in some way was concealed in the wall of the room. He requested me to stand, as well as I remember, about six feet from the wall facing me, and to agitate the atmosphere by ejecting a breath as though in the act of giving a low whistle. Each time I did so, there came from some other part of the building a sound similar to that produced by striking a large gong.

I had repeated successfully with a simple commutator most of the experiments reported to have been made by Professor Hughes, but I was still in doubt whether I fully understood the subject or not, as I had read of "two wave-currents running through the circuit, one of electricity, the other of sound vibrations," &c. I was, therefore, pleased to have the opportunity of witnessing the experiments, and hearing the lecture on the microphone given by Mr. W. H. Preece, assisted by Professor Hughes, at the Society of Telegraph Engineers, on the evening of the 23rd ult. In the discussion which followed, there appeared to be a difference of opinion as to the law on which the microphone acted, but if I had required further evidence to strengthen my assertion that the microphone was simply a sensitive commutator, I should have found it in the experiments which were exhibited.

Mr. Preece told us that Professor Hughes's first experiment was to include a length of copper wire in circuit with a battery and telephone. While so placed, he plucked at it, talked to it, and stretched it without effect until the wire broke, and then he heard a slight sound at the telephone, and he reproduced the sound whenever he rubbed the ends of the wires together. That being so, what can molecular changes in the material, and two wave-currents running through the circuit, one of electricity, and the other of sound vibrations, have to do with it?

Mr. Preece then exhibited the experiment of placing a timepiece on a vibrating board, when the beat of the pendulum could be distinctly heard on the telephone at the most distant part of the room; but, when the clock was removed from the board, no such sound was audible, and why? Because on the board was fixed a sensitive commutator which was affected by the vibrations of the pendulum, and this kept up a continuous make and break of a circuit in which were placed the battery and telephone.

Again, when Professor Hughes wrote an imaginary letter on the vibrating board, of course the pressure of the pen affected the commutator, and a sound was produced on the telephone. When he disconnected the commutator, nothing was heard but the scratching of the pen upon the paper.

Mr. Preece stated that Professor Hughes had obtained wonderful results from placing his gold watch-guard in the circuit and shaking it. Of course it would be so. The chain so placed would be analogous to an intermittent contact. I would illustrate what I mean by intermittent contact by what occurred some years ago in an underground wire which was laid in a trench two feet deet deep by the side of a railway. It was a copper wire covered with gutta percha, the wire was broken, but the two ends pressed close together, and did not show any signs of being broken until a train passed close by the spot where it was laid, and then the vibrations caused by the motion of the train produced the intermittent contact.

The same remarks will apply to the five pieces of mercurially-prepared carbon, which were enclosed in the glass tube and used by Professor Hughes as a microphone.

When a telegraph operator is sending a message to be received on the Morse instruments he works the commutator, or key as it is more frequently called, with his hand, and gives time-contacts—that is to say, to form a *dash* the contact remains double the time necessary to form a *dot*. Professor Hughes, if I understand it rightly, has discovered that, by allowing the breath to impinge upon a sensitive commutator, contacts of varying duration are made which are faithfully reproduced in corresponding sounds upon that marvellous instrument the telephone. This is an important discovery, and must henceforth identify Professor Hughes with the telephone. By this discovery the telephone at once becomes a thoroughly practical and useful instrument, not only for telegraphic purposes, in the ordinary acceptation of the term, but it can be utilised in endless ways. By the magnitude and number of beats on the telephone, the engineer can learn the amount of vibration caused by heavy weights passing over new or old structures; a soldier can discern the approach of an enemy miles distant, and, whether it be the tread of cavalry or the rattle of artillery, it can be distinctly distinguished. By these commutators, or microphones, being conveniently placed in the room where an eminent man, say in London, is speaking to an audience on scientific or other subjects, he can be as distinctly heard by an audience assembled in any room where a telephone is placed in the same circuit. If the microphone will do all that its discoverer claims for it, there is no reason why friends or foes should not be able to converse with each other, although thousands of miles of land or sea may divide them. The low current generated by the telephone is not sufficient to overcome the electro-static induction of submarine cables or underground wires, but, with the microphone as a sender, the electro-motive force can be whatever is required.

Professor Hughes, by this discovery, has added an important leaf to the branch of our electrical knowledge, and I most heartily congratulate him.

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ON THE ELECTRICAL CAPACITY OF A LONG NARROW CYLINDER AND OF A DISK OF SENSIBLE THICKNESS. By Professor CLERK MAXWELL, F.R.S.*

The distribution of electricity in equilibrium on a straight line without breadth is a uniform one. We may expect, therefore, that the distribution on a cylinder will approximate to uniformity as the radius of the cylinder diminishes. Let $2\,l$ be the length of the cylinder and b its radius; ξ the distance of a point on the axis from the middle point of the axis, and let η be the distance of any point from the axis. Let r_1, r_2 be the distances of any point from the positive and negative ends of the axis, so that—

$$r_1^2 = (l - \xi)^2 + \eta^2,\ r_2^2 = (l + \xi)^2 + \eta^2.$$

Let λ be the linear density on the curved surface of the cylinder; that is, let $\lambda d\xi$ be the charge on the annular element $d\,\xi$. Let σ be the surface density on the flat ends. Then at a point on the axis for which $\xi = x$, the potential (ψ) is—

$$\psi = \int_{-l}^{+l} \lambda \left[(\xi - x)^2 + b^2\right]^{-\frac{1}{2}} d\,\xi + 2\,\pi \int_0^b \sigma\,\eta\,\left[(l - x)^2 + \eta^2\right]^{-\frac{1}{2}} d\,\eta + 2\,\pi \int_0^b \sigma\,\eta \left[(l + x)^2 + \eta^2\right]^{-\frac{1}{2}} d\,\eta$$

the first integral being extended over the curved surface, and the other two over the positive and negative flat ends respectively. If the electricity is in equilibrium in the cylinder, ψ must be constant for all points within the cylinder, and therefore for all points on the axis. Also, by Article 144 of "Electricity and Magnetism," if ψ is constant for all points on the axis, it is constant for all points within the surface of the cylinder. If λ and σ be supposed constant,

$$\psi = \lambda \log \frac{(f_1 + l - x)\,(f_2 + l + x)}{b^2} + 2\,\pi\sigma\,(f_1 + f_2 - 2\,l)$$

where f_1 and f_2 are the distances of the point (x) on the axis from the positive and negative edges of the curved surface. At the middle of the axis $x = o$, $f_1 = f_2 = \sqrt{l^2 + b^2}$,

$$\psi_0 = 2\,\lambda \log \frac{f + l}{b} + 4\,\pi\,\sigma\,(f - l)$$

At either end of the axis, $x = l$, $f_1 = b$

$$\psi_l = \lambda \log \frac{4\,l}{b} + 2\,\pi\,\sigma\,b$$

At the curved edge, $\psi_e = \lambda \log \frac{4\,l}{b} + 4\,\sigma\,b$

Just within the cylinder, when it is just less than l,

$$\frac{d\,\psi}{d\,x\,(l)} = -\,\lambda\left(\frac{1}{b} - \frac{1}{f}\right) + 2\,\pi\,\sigma = o, \text{ by hypothesis.}$$

Hence, $2\,\pi\,b\,\sigma = \lambda$; or the density on the end must be equal to that on the curved surface.

The whole charge is, therefore, $E = 2\,\pi\,b\,\sigma\,(2\,l + b)$,

The greatest potential is, $\psi_{(o)} = 2\,\pi\,b\,\sigma\left(2 \log \frac{2\,l}{b} + \frac{b}{l}\right)$

The smallest potential is $\psi_{(l)} = 2\,\pi\,b\,\sigma\left(\log \frac{4\,l}{b} + \frac{2}{\pi}\right)$

and the capacity must lie between

$$\frac{E}{\psi_{(o)}} = \frac{2\,l + b}{2 \log \frac{2\,l}{b} + \frac{b}{l}} \quad\text{and}\quad \frac{E}{\psi_{(l)}} = \frac{2\,l + b}{\log \frac{4\,l}{b} + \frac{2}{\pi}}$$

These are the limits between which Cavendish shows that the capacity must lie.

To obtain a closer approximation Professor Maxwell neglects the effect of the flat ends, and considers the cylinder as a hollow tube.

Let Q be the potential energy of any arbitrary distribution of electricity on the cylinder,

$$Q = \tfrac{1}{2} \int_{-l}^{+l} \lambda\,\psi\,d\,\xi$$

The charge is $E = \int_{-l}^{+l} \lambda\,d\,\xi$.

If the charge be now supposed to distribute itself so as to pass into the state of equilibrium, then the potential will become uniform and equal, say, to ψ_o and $Q_o = \frac{1}{2}\,\psi_o\,E$.

If K be the capacity of the conductor, $E = k\,\psi_o$ and $K = \frac{1}{2}\frac{E^2}{Q_o}$ Since Q, the potential energy, due to any arbitrary distribution of the charge, may be greater and cannot be less that Q_o, the energy of the same charge in equilibrium, the capacity may be greater but cannot be less than

$$\tfrac{1}{2}\,\frac{E^2}{Q} \quad\text{or}\quad \frac{\left[\int_{-l}^{+l} \lambda\,d\,\xi\right]^2}{\int_{-l}^{+l} \lambda\,\psi\,d\,\xi}$$

This inferior limit of the capacity is greater than that derived from the maximum value of the potential, and often gives a very close approximation to the truth. Thus, if we suppose, in the case of the cylinder, λ to be uniform,

$$E = 2\,\lambda\,l,\ Q = 2\,\lambda^2\,l\left(\log \frac{4\,l}{b} - 1\right),\ k_0\ 7\ \frac{l}{\log \frac{4\,l}{b} - 1}$$

To obtain a closer approximation Professor Maxwell supposes the distribution to be of any form, and to be expressed in the form of a series of Harmonics. The potential due to any such distribution on a straight line may be expressed in terms of spherical harmonics of the second kind by the method of Heine and Neumann. In this case, at a point at a very small distance b from the line, he gets

$$K_2\ 7\ \frac{l}{L - 1 - \frac{5}{36}\,\frac{1}{L - \frac{101}{30}}}$$

Where L is the value of L, when $\xi = l$, and $L = \log, \frac{r_1 + l - \xi}{b} \log \frac{r_2 + l + \xi}{b}$ and r_1, r_2 the distances of the given point from the ends of the line. Since L is a large number, when the length of the cylinder is very great compared with its radius, this approximation does not differ much from the first approximation K_0. Or to a further approximation:—

$$K_4\ 7\ l \div \left\{ L - 1 - \frac{5}{36}\cdot\frac{1}{L - \frac{101}{30}} - \frac{9}{400}\,\frac{\left(L - \frac{457}{210}\right)^2}{\left(L - \frac{101}{30}\right)\left[\left(L - \frac{101}{30}\right)\left(L - \frac{6989}{1260}\right) - \frac{45}{196}\right]} \right\}$$

[For the further conditions on which K_2, K_4 depend we must refer to the paper itself.]

If the length of the cylinder is 7·245, its diameter $L = \frac{101}{30}$, and the denominators of K_2, K_4 become infinite. These expressions are approximations to the true values only when the ratio of the length to the diameter is much greater than this, in which case we may consider as a sufficient approximation:

$$K = \frac{l}{\log \frac{4\,l}{b} - 1}$$

Professor Maxwell proceeds to apply the above method to determine the capacity of a disk of radius a, and thickness b, b being very small compared with a. He supposes that the density on the flat surfaces is the same as when the disk is infinitely thin. He gets as a first approximation to the capacity—

$$K\ 7\ \frac{2}{\pi}\left\{a + \frac{b}{2\,\pi}\left(\log \frac{a}{b} + 2\right)\right\}$$

R. T.

* Abstract of a Paper communicated to the London Mathematical Society, March 14th, 1878. Made with Professor Maxwell's consent.

The Telegraph Congress, which was to meet in London in July next, has, we learn, been postponed; but Mr. Patey, one of the Assistant Secretaries of the General Post Office, has been sent to Berlin to discuss with the German Director-General of Posts certain important alterations which it is proposed to make in the telegraph arrangements between England and Germany.

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CORRESPONDENCE.

THE MICROPHONE AND TELEPHONE.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: It has been stated in two or three quarters, and your account of the microphone repeats the statement, that on slightly pressing the glass tube containing the carbons, Professor Hughes obtained a deflection on the galvanometer in one direction, whilst a tensile strain on the tube produced a deflection in the other direction. Is not this an error? If the statement is true —and I do not find it verified by experiment—there is something other than the mere alteration of the circuit's resistance involved in the process. But it is difficult to conceive that with a current of uniform direction a change of deflection, except in the extent of it, can be brought about by compression or expansion of the conducting medium.

Another statement which is somewhat misleading has found its way more than once into into the columns of *Nature*, and has been copied for the benefit of those who are interested in the telephone. It is to the effect that if the sending magnet is tapped by a *diamagnetic* body, such as a piece of copper, the taps are heard at the receiving end. That is so, but the diamagnetic character of the tapper has nothing to do with the effect. Any concussion producing sonorous vibrations in the transmitting magnet will give rise to sound in the receiver. I should have thought the fact was well known by this time. I tried it almost immediately the telephone came to this country, and I got precisely what I expected to get. Rightly or wrongly I argued the matter in this way: practically the diaphragm, occupying the position it does, is merely a detached portion of the magnet; therefore any vibration of the magnet itself ought to disturb the field and set up currents. It certainly did so, no matter where the blow was struck. Under certain conditions a diamagnetic diaphragm or armature will produce feeble currents of the kind we are speaking of; but when we come to *tapping* the magnet, the resulting disturbance is in no way concerned with the character of the tapper.

27th May, 1878. JAMES LAISTER.

IS THE BODY AN ELECTRIC MACHINE?

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Allow me to bring the following (to me) strange phenomenon under the notice of your scientific readers. To many of them doubtless it will not be *strange*, and they will be able to account for it.

I have frequently observed during the past winter, on removing the innermost garment (a flannel vest), that its under surface has been *highly luminous*.

Sometimes this light is of a pale phosphorescent hue, like winter or sheet lightning; but often it assumes an angry red, like the forked does, and in this latter case, when the house has been quite silent, I have distinctly heard that crackling sound identical with the electric spark.

Is it possible that our bodies resemble so many Leyden jars fully charged? and that the flannel acts like the silk "rubber" in producing electricity by friction on the person? and all this without any aid from Pulvermacher's apparatus.

Let me add that I have noticed the above phenomenon only on *dry, frosty nights*, and that on undressing I have *hastily* taken off the fiery vest and thrown it *briskly* to some three or four feet distance.

I shall leave it to some of your learned readers to account for all this. I can only assure them I was not mistaken, as I have often and closely observed it.

I hail with pleasure the appearance of your excellent paper, *The Electrician*.

Hoping some correspondent will enlighten me on the foregoing. —I am, sir, your obedient servant, W. S. O. B.

CABLE STATIONS.

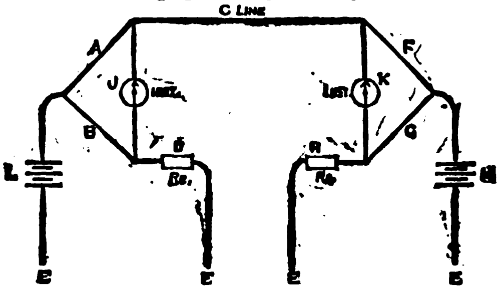
TO THE EDITOR OF THE ELECTRICIAN.

Sir: I am not altogether eager to take up the cudgels on behalf of the companies. No doubt, abler men will do that; but I must at once raise the question as to the accuracy of "E. A.'s" strictures as stated in your issue of last week. So far as I know, the managers of the companies do everything your correspondent intimates they fail to do. At all the cable stations with which I am acquainted there are good libraries; whilst, for those who do not care so much for sedentary occupation, we have billiards, besides our boating and athletic clubs. In the evening our piano gives forth no uncertain sound, and, in fact, everything is done to make the monotony of our existence less monotonous. As for selection, what would you have in these days of competition? I know I had to study previous to obtaining my post. "E. A." should know that, even were his statements true in any one case, the majority of managers do take all possible care and interest in the welfare of those in their employ. TELE.

STUDENTS' COLUMN.

ANSWERS TO QUERIES.

3. *Duplex Working.—Wheatstone's Bridge Method.*—Perhaps a rough sketch of a Wheatstone bridge duplex will be of more assistance than a whole page of explanatory remarks.



Arms A and B equal say 100 ohms each; C and D equal 2000 ohms each. If L is sending to M no current will pass through Inst. I. Should Station M wish to send at the same time, the equilibrium of the current is disturbed, and signals recorded at I. Reverse the order, and signals will be recorded at M. Further and fuller particulars will be found in Culley's 6th edition, and Preece and Sivewright's text book.

4. *Joint Resistance.*—The rule for finding the joint resistance of two wires is to divide their product by their sum, thus—

$$\frac{75 \times 125}{75 + 125} = 41{\cdot}875 \text{ joint resistance.}$$

The two wires having a resistance of 75 and 125 are in proportion of 3 and 5. If, therefore, the 25 farads be divided into 8 parts, 5 parts, or 15·625, will go by the wire containing 75 ohms, and 3 parts, or 9·375 farads, by that with 125 ohms.

WM. DENNETT, Dover P.O.

5. *Electrolysis of Water.*—The question proposed on page 12 was, I believe, originally set by Professor Tyndall in one of the science examinations. Dr. Elam, in a recent number of the *Nineteenth Century*, says the fact is incorrect, and that a single cell will decompose water, inasmuch as it polarises. Mr. Prescott, in his admirable work, says:—"It is manifest that where oxygen or hydrogen is set free at any point in a galvanic circuit they will tend to send a counter current. This tendency is called galvanic polarization. This accounts for the fact that no single galvanic pair can decompose water, as the force generated is no greater than the force of the counter current that would be produced by the liberated gases." SCIENCE.

QUERIES.

7. In what does *potential*, as applied to electricity, differ from *potential* as applied to energy? J. DAVIES.

8. Would one of your readers connected with the Postal Telegraph Department be good enough to inform me what steps I must take to get an appointment in the department? J. W.

9. Can any one tell me of a simple work on electric bells, telephones, &c., suitable for amateurs? F. W. J.

SOCIETY OF TELEGRAPH ENGINEERS.

A special general meeting of this society was held on Thursday evening, the 23rd of May, at the institution of Civil Engineers, Great George-street, Westminster. The chair was occupied by Dr. Siemens, the President, and there was a very large attendance.

After the formal business was disposed of,

The PRESIDENT said they had a communication from Lieutenant Savage [the officer in charge of telegraph and signalling in India] upon some experiments regarding the telephone, which were remarkable in themselves, and which would form a good introduction to the chief communication of the evening.

Mr. WEBB then read Lieut. Savage's communication, which was dated "Field Telegraph Office, Roorkee, March 7, 1878." In the course of his remarks the writer said: I have been making splendid big telephones lately, and they will do anything—almost talk of themselves. I have large ones now that are almost too heavy to lift, and they *do* speak out—they make nothing of very long distances. I have gone regularly to work, and I find the sending telephone is of the two the one to aim at. I tried improving the receiving telephone, but there is no very wide field for improvememt in it. It is impossible to increase a current of electricity without expending energy on it in some way, and it seems impossible to apply energy in any shape to increase the current as it arrives to the receiver; so in the receiving telephone it is only necessary to take the current as it comes, and get the most possible work out of it by having a highly magnetised magnet, a coil of tolerably high resistance in comparison with the total resistance in circuit, and a thin, very thin, vibrating disc, so as to oppose the work as little as possible. But in the sending telephone I

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have found the greatest advantage by having large ones—large strong magnets 18in. long and ½in. section (diameter), coils of very high resistance placed advantageously, and a large thin vibrating disc 6in. across, and a large open mouthpiece 2½in. across. One I have just completed of this size seems as if the sender was shouting in one's ear. I am going to try about 400 miles with this one to-morrow. I have had some telephones supplied to me by the Government (Telegraph Department), but they are no use at all, so I have not been able to get a wrinkle from them. I made the current from a telephone induce a current in another separate coil, this separate coil being circuited through a receiving telephone as follows:—I wound about 300 ohms of fine wire on an iron core, and on top of this I wound about 300 more ohms; the former coil was circuited through the sender (70 miles off), the latter separate coil was on to my receiving telephone. I heard quite distinctly with the induced current, but of course no better, as there was no energy expended to increase the current; it was a pretty experiment, that was all. I fitted a vibrating disc above the ends of the iron core and magnetized the iron core. The coil became a telephone, and as work was done in vibrating this last disc I could hardly hear anything on the regular telephone. It was rather a neat way of changing sound into vibrations, vibrations into electricity, electricity into magnetism, magnetism into induced current, induced current into magnetism, magnetism into vibrations and sound. The limit of the sound that can be produced by a telephone is the amount of energy which can be expended by voice on the senders's telephone. I mean that it is advantageous to expend a considerable amount of energy on the sender's vibrating disc, and to convert as much of this energy into electricity as possible. Voice energy is the source of electricity, and I think the limit of voice energy must be the limit of electricity, converting the voice energy into as much electricity as possible by proper apparatus. Voltaic electricity can be increased by increasing the number of cells, but the voice has its limit. I do not think that the current sent by a powerful telephone is so small, so very small. I think the reason it does not affect a sensitive galvanometer is because it is reversed so many hundred times or thousand times a second that it never has *time* to operate on the galvanometer needle. Somehow I do not think that the limit of telephones for speaking will be found to be in the amount of electricity generated, but it will be found first in the fact that this kind of electricity seems to travel slower at the receiving end of a long line than at the originating end. Hence, of course, another sound is commenced before the previous one is completed. I use large plates to get amplitude of vibration. The greater the amplitude of disc vibrations—so long as correct tones are emitted—the greater the quantity of electricity. Also the loudness of the note sounded by the sender is in proportion with the square of the amplitude of disc vibration; and the greater the mass of the vibrating disc the more current is originated. I think that the resistance of the coils of the sending telephone ought to be about equal to the total resistance of the circuit—exclusive of other telephones. Has any one satisfactorily proved that it is the approach and recession of an iron disc to a magnet? Would you be very much surprised to hear that it was the vibrating particles of the magnet, while the coil does not vibrate, so the lines of force which are permanently attached to each atom are cut by the coil when they vibrate? I thought this two months ago. I wonder if there is anything in it—that the particles of the bar magnet vibrate longitudinally. I don't think there is much in this, but it seems queer that the following should happen: I take off the vibrating disc of a telephone and I tap a thick bit of brass on the end of the exposed magnet. This tapping I can hear on a distant telephone. Is it only because brass may be called in some degree a magnetic substance, though in a small degree, or have particles (magnet) vibrating got anything to say to it? Similarly, I have been able to hear talking when using a brass vibrating disc instead of iron, though, of course, very much fainter. The explanation is because brass is more or less a magnetic substance (principally less). But it would seem that, although Prof. Bell's explanation of his telephone is evidently correct, still you can transmit sounds by making the magnet or coil vibrate relatively to each other. If you take off the iron vibrating plate of a telephone and connect it in circuit with another telephone—if you tap any portion of the telephone which has no disc—the wood case, coil, magnet—with anything you like, you can hear that tap transmitted to the other telephone. I suppose the tapping disturbs the relative positions of coil and magnet, and so the lines of force of magnet are cut by the coil. Hence a current, which is transmitted to the other telephone. So, why cannot one make a telephone on this principle also—a vibrating magnet and a permanent fixed coil, or *vice versâ*, and no iron disc?

The customary vote of thanks having been passed to Lieut. Savage,

Mr. PREECE was introduced, and was warmly received. He delivered a lecture on "The Connexion Between Sound and Electricity," illustrating his remarks by Professor Hughes's recent discoveries. At the outset he observed that a late member of the present Ministry, at a dinner given by the institution whose hospitality they were receiving in that hall, stated, on the authority of one of the leading members of the engineering profession, that inventions, like cocktails and Colorado beetles, had taken root in America, and deserted Old England. It was therefore to him—as he believed it was to those present—very gratifying to have brought before them an invention which was the offspring of British soil. During the last few months the science of acoustics had taken marvellous and rapid strides. First of all they had the telephone, which enabled them to transmit human speech to distances far beyond the reach of ear and eye. Then they had the phonograph, which enabled them to reproduce sounds uttered at any place and at any time; and now they had, he might almost say, a still more wonderful instrument, which not only enabled them to hear sounds that were absolutely inaudible, but also enabled them to magnify sounds that were audible. In other words, the instrument he had the pleasure of bringing before them that night was one which acted towards the ear in the same capacity that the microscope acted towards the eye. The telephone and the phonograph depended essentially on the fact that the mere vibration of a diaphragm could reproduce all the tones of the human voice, but in this new instrument diaphragms were cast aside, and they had the direct conversion of sound-waves into the form of electrical action. If it had been the habit or custom of this society to give to the papers and discourses delivered sensational titles he should have been inclined to call his remarks that night "A Philosopher unearthed" [hear]. Professor Hughes was known to them all, having been connected with the society more or less from its first inception, and his works, though few, were known, because they were sound. The chief characteristic of this "Philosopher" was his extreme modesty. Had Professor Hughes been left to himself, he (the speaker) did not believe they would have had this pleasure; but, by a lucky chance, he was admitted into the "Philosopher's" secrets, and he was that night enabled to bring before them Professor Hughes's labours; and they had been labours, for month after month he had been striving at this idea, which he had at last elaborated into the microphone. The chief characteristic of the labour and apparatus he was about to introduce was its extreme homeliness, its extreme roughness, and its absurd simplicity. With common nails, common pieces of wood, with a halfpenny money-box, with common sealing-wax, with the ordinary apparatus which every child had at his command, he had been enabled to attack nature in her strongholds, to ask her questions and receive answers, and to lay before them facts and truths which, although they existed from time immemorial, were brought to light for the first time [applause]. With these introductory observations Mr. Preece proceeded to deliver his lecture proper, the essential features of which, together with the diagrams to which he referred in illustration of his remarks, appeared in *The Electrician* of last week. The lecturer was very frequently interrupted by the applause of his audience.

The PRESIDENT, at its close, said they had been listening to a very interesting and instructive address, and he hoped it would be followed by an equally interesting discussion which he called on the Duke of Argyll to open.

The Duke of ARGYLL, after expressing his pleasure at the opportunity which had been afforded him of being present, spoke of the extreme interest with which he was sure they had all heard the admirable lecture which had just been delivered by Mr. Preece—one which for interest of matter and for clearness of exposition he had never heard excelled in the course of his experience of scientific lectures [applause]. It was quite clear that they were in the presence of one of the most remarkable discoveries of an age which was full of discoveries—discoveries which were sure to be utilised in a thousand ways which they could not at present foresee. Mr. Preece said he rejoiced that, on this occasion at least, the progress of discovery had taken place on English soil; but on further inquiry he (the noble Duke) was not sorry to find that the distinguished man whose discovery had been explained that night was himself, although resident in this country, a citizen of America. In matters of science he was one of those who were thoroughly cosmopolitan; and he was also one of those who felt that the citizens of America were, after all, our fellow countrymen. With regard to the uses to which this discovery might be put, there were many which immediately suggested themselves to one's imagination. He could not doubt for one moment that one of the most immediate applications of this most valuable discovery would be a surgical application. He confessed he was struck with some of the possible inconveniences which it might occasion; and, if it were a fact that one of these little boxes set in any room would repeat at unknown distances all the conversation in that room, Professor Hughes would have to provide them with an antidote for his own discovery [laughter].

Dr. LYON PLAYFAIR sympathised with the remarks of the Duke of Argyll—in fact, one saw no end of applications to this discovery. He had no doubt that before long Profesor Hughes would connect this instrument with the ærophone, which magnified sounds so that one could hear a sound over four or five square miles. He thought it would throw much light on many scientific phenomena with which we had got acquainted, and when these instruments were developed it was perfectly impossible to know what might come from this discovery.

Mr. WILLOUGHBY SMITH rather differed from Mr. Preece as regarded his theory. He himself thought it was simply a matter of contact. He described several experiments on the black-board in illustration of his theory. They had heard of hearing the tramp of a fly by means of the microphone. He had a dark box containing silenium which was therefore obscured from the light; but on allowing a ray of light to impinge upon the silenium a blow like that from a Nasmyth's hammer was heard at the receiving end of the circuit. He was inclined to think that what Professor Hughes had introduced was a very sensitive commutator.

Mr. LATIMER CLARK noticed an omission which Mr. Preece had made in his lecture, inasmuch as Professor Hughes's experiments had given them a very delicate thermopile, which the lecturer had failed to notice. [A description of this appeared in *The Electrician* of last week.] He thought a very excellent Morse instrument might be made from the microphone.

After a few remarks from Lord LINDSAY,

Professor GRAHAM BELL said no one could more heartily congratulate Professor Hughes upon his great discovery than he did, and of course he (the speaker) and all present, were interested in the cause of the strange effects they had from the telephone. He thought all those who investigated telephonic effects would realize that a new science altogether was being investigated. They had discoveries yet in store for them. He must confess that the explanations afforded by Mr. Preece and by Mr. Willoughby Smith were to his mind unsatisfactory. There were certain points in the telephone itself which might guide them to the true solution of this problem. The laws of audibility in electric currents by the telephone were precisely analogous to the laws of indication. Hence when they obtained a sound from a telephone they had a change in the intensity of the current. The difference between the maximum and minimum intensity of a current was very great, for a sound could only proceed from a difference in the intensity of the current. He was more inclined to take Mr. Willoughby Smith's explanation than that shown to them by Mr. Preece. If he might venture to offer a suggestion, he should think it was probably a variation in the amount of the contact. "You probably have a large number of particles in contact, and as the mass is thrown into vibration more or less a larger or smaller number of particles come into contact. Hence you have a variation in the resistance of the circuit without an actual break of the current." However, he thought the whole subject required further investigation. He had himself during the last few days carried on some experiments with a microphone, and he had been struck by the appearance of a very curious noise, which recalled to his mind some experiments he made some years ago. No doubt, there was a vast field here for discovery, and he should merely offer his congratulations to Professor Hughes.

Professor HUGHES, who was warmly received, said it seemed that the theory of the microphone was not very well understood, and he could readily understand this. So far as he could go with all his experiments, they showed that it was, as he had said, an increasing and diminishing resis-

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tance. Mr. Willoughby Smith thought it was contact, and this was right, too, only it was not followed from the point from which he (the speaker) followed it.

The PRESIDENT, after the close of Professor Hughes's remarks, observed that, as time was wearing on, he would like to make a few remarks on the very interesting matter which had been brought before them. He thought all must have been pleased to have seen how two great discoverers had discussed and brought before the meeting their particular views regarding certain action in these two instruments, which, when they came to compare them, would be found to have many points of analogy, which, although essentially different in many respects, all tended towards one great end. Mr. Preece and Professor Graham Bell differed with regard to the mode of action which took place in this microphonic instrument, but he thought there was probably not so much difference between the two theories. It was quite evident that the action of the microphone was due to varied resistance, and the question for them to consider was only how that resistance varied by the vibrations. Referring to Mr. Edison's discovery, he said he should have liked to hear more about the phonograph, because these three discoveries appeared to him (the speaker) to form one great advance in our physical knowledge regarding not only the transmission of sound or the record of sound, but regarding the transmission of electricity into almost all the physical forces. They had heard from Mr. Willoughby Smith that a ray of light could be made to announce itself like a clap of thunder, and he could quite follow that gentleman in his argument. The Duke of Argyll alluded to another application of these discoveries—physiology, and he wished that physiologists had taken part in this discussion, because he believed himself that the influences of this discovery on physiological research would be very great indeed. Speaking of the remarkable effects of the phonograph, he said we had a physical record of the succession of sound. This struck him as being an exceedingly analogous case to the impress produced on our brain by what we hear or see. An impress was produced which for the moment seemed lost, but which at any time in a vigorous mind could be reproduced. Memory was not conceivable on any other hypothesis but in a mechanical record being left on the brain, and left there for half a century, perhaps, to be "worked off" in the succession in which it had been laid down there. He did not think they could feel too thankful to those gentlemen who had brought these matters before them, as it had enabled them to discuss them as they had done. He therefore moved a hearty vote of thanks to Mr. Preece, reminding the meeting at the same time that their thanks were due to the great discoverers who were present, and who had given them the benefit of their personal views. He, therefore, also proposed a hearty vote of thanks to Professors Hughes and Bell.

The meeting cordially passed the votes.

Mr. PREECE, in reply, reminded the meeting that when he spoke on the theory of the subject he had not time to enter into it. There was no difference between the views enunciated by Mr. Willoughby Smith, Prof. Hughes, Prof. Bell, and himself; the only difference was a difference of language [hear, hear]. Whether the variation of the current was due to differences of contact or pressure mattered very little provided they used contact and pressure to imply the same. Where he used pressure he meant contact, and where Mr. Smith used contact he meant pressure. It had been a very great pleasure to him to bring this subject before the meeting. He had had within the last twelve months the pleasure of introducing before a British audience the telephone and the microphone, and he hoped that next year he should be able to bring before them fresh novelties and new discoveries [hear, hear]. He had been anxious that Professor Hughes should have brought before them his own discovery, but that gentleman would not undertake to do it.

RECENT PATENTS.

3597. ELECTRIC TELEGRAPHS, *F. H. W. Higgins. Dated September* 25, 1877. *(Not proceeded with.)*—ED.

This invention has for its object the production of audible signals through submarine cables. A disc or sheet of iron under the influence of a magnet responds by a ticking sound to any alteration in the strength of the current flowing around the latter. These alterations may be produced in the usual manner by the application of an electric current, or better still by means of an induction coil so arranged at the receiving end of the line as to generate a secondary discharge upon the commencement of the signalling current, and another at its termination, or diminution or other alteration in the strength of the electric wave. For this purpose is employed for the magnet an electro-magnet wound with a coil permanently connected with a battery, and also with another coil coupled at its ends to the ends of one of the coils of an induction coil, the other coil being connected with the cable, and earth. Or the electro-magnet may have around it a coil in connection at one end with the cable, and at the other end with a condenser of small capacity, the other plate of which is to earth. If the current from the cable or the discharge from the induction coil is in a direction to increase the strength of the electro-magnet, the sound produced is less than if the current is in the opposite direction.

3726. DUPLEX TELEGRAPHIC PRINTING APPARATUS, *G. L. Van der Ploeg.—Dated 8th October*, 1877.—*(Complete.)* 8d.

The manipulator is constructed with a handle which in several revolutions causes an axis carrying a wheel to make one revolution. The wheel makes or interrupts the contact in the line current, and it carries a bar, causing an oscillation to the reverser or commutator. Thus the current is reversed according to the direction in which the handle is turned. When the balance of the speaker and the reinforcer is at rest, one of its arms is in contact with a point and allows the current of the battery to pass. When the rod is pushed down, the arm retires from its point of contact, but before doing which the other arm touches its point of contact so that the poles of the little battery are closed, and the current passing through the bobbins attracts the armature, and thus makes a noise or sound. On pushing the rod still further down, the first arm leaves its point of contact, and the current which passes through the manipulator is considerably reinforced. The current coming from the point of departure to the receiving apparatus, and converting the electro into a magnet with two ends, is interrupted, reversed, and strengthened by the action of the manipulator. The printing apparatus is actuated by arms fitted to the armature of each electro, working tangents engaging with a pin wheel running backwards and forwards. The pin wheel turns an axis bearing a double-margined type wheel corresponding to the characters on the dial of the manipulator.

3743. MAGNETO-ELECTRIC MACHINES, *J. H. Johnson.—Dated 9th October*, 1877.—*(A Communication)*. 6d.

Electric light is produced by currents alternately positive and negative. The frame is of the form of a St. Andrew's cross, and serves to support a series of horse-shoe magnets, arranged at right angles to each other, and also bearings to carry a shaft provided with a suitable number of cylinders. Each magnet is formed of a set of magnetised blades converging towards the centre of the frame. A sufficient space is left between two consecutive series of magnets for the reception of one of the cylinders, each of which carry induction coils or bobbins, secured by bands of copper insulated by sheets of paper, in recesses formed in the periphery of each cylinder. The bobbins are composed of a double tube of soft iron split through its entire length, and having coiled thereon copper wire covered with cotton, and insulated by a balsamic composition. Each bobbin when it passes in front of the pole of a magnet receives a direct current on approaching it, and an inverse one on receding from it. It thus becomes the recipient of a large number of reciprocating currents which are conducted to one ring by wires and are transmitted by a rod to one of the bearings, where they are collected and distributed through two wires leading to binding screws, and are subsequently directed to an electric lamp or other receiver.

3750. ELECTRO-MAGNETIC HYDRAULIC ENGINE, *W. R. Lake.—Dated 9th October*, 1877.—*(A communication.)*—*(Not proceeded with.)* 2d.

The base is a horizontal disc near the periphery of which are pillars supporting a hollow ring divided into two compartments, in each of which is a cylinder, the piston rods of which are connected by a beam. Holes are bored in the ring, and are fitted with piston-like stoppers, each being connected to a box surrounding the ring, and moving freely up and down the pillars. The bottoms of the boxes are of soft iron, and beneath them are arranged electro-magnets attached to the base plates.

INVENTIONS PROTECTED FOR SIX MONTHS ON THE DEPOSIT OF COMPLETE SPECIFICATIONS.

1882. Improvements in TELEPHONES and in apparatus connected therewith, Joshua Franklin Bailey, Charing-cross, London.—A communication from Elisha Gray, Chicago, U.S.—*10th May*, 1878.

1917. Improvements in TRANSMITTING and RECEIVING ELECTRICAL and TELEPHONIC EXCITATIONS and in the construction and use of the apparatus employed therein, Arthur Samuel Hickley, Prince of Wales-crescent, Kentish Town, London.—*13th May*, 1878.

1800. ELECTRICAL APPLIANCES, John Faulkner, Manchester.—*14th May*, 1875.

SHARE LIST.

TELEGRAPHS.

SHRS.	PD.	COMPANIES.	Th., 23rd.	F., 24.	S., 25.	M., 27.	Tu., 28.	W., 29.
			BUSINESS DONE.					
Stk.	100	Ang-American (1)	59¾ 60¼	60	—	60¼ ½	59 ½	acc 60¼
Stk.	100	Do. Preferred	—	—	88½	88 ½	88½ ½	88½, acc 88½
Stk.	100	Do. Preferred (a)	—	—	32½	—	—	—
10	All	Brzn-Submarine..	6 13-16	—	—	6¾ 13-16	6 11-16	—
10	All	Cuba (Limited) ...	9½	—	—	—	—	—
10	All	Do. 10 p. c. Pref..	—	—	—	—	—	15¾ 16
10	9	*Drct. Spanish (1)	—	—	—	—	—	—
10	All	Do. 10 p. c. Pref..	—	—	—	—	—	—
20	All	Dct. U.S.Cable(1)	—	13¼ x d	13¼ x d	—	—	—
10	All	Eastern (Lmtd.).	7½ ⅝	7½ 9-16	7 7-16 ½	7 2-16 9-16	7 7-16	acc 7 9-16 ⅝
100	All	Do. 6 p. c. Deben.	—	—	—	—	106½	—
100	All	Do. 5 p. c. Deben.	—	—	—	—	—	—
10	All	Do. 6 p. c. Pref. ..	—	—	11⅜	—	—	acc 11⅜
10	All	Estrn.Ex., Aus., and China	7¾ 11-16 ⅝	7⅝	7 11-16 ⅝	7½	7½	acc 7¾ 13-16
100	All	Do.6p.c.Deb.,1875	—	—	—	—	—	—
10	All	Gmn.Un.Tl.&Tst.	—	—	—	—	—	8 3-16
10	All	Globe Tl.&Tst.(1)	5½	5½	[illegible] 5	5½	—	acc 5½
10	All	Do. 6. p. c. Pref..	10¾	10½	10¾ ½	—	10½	10½
10	All	Great Northern..	—	—	—	8 1-16	8 8½	acc 8½
25	All	Indo-European ...	—	—	—	—	—	—
10	All	Mediter. Ex. (1)..	—	—	—	—	—	—
10	All	Do. 8 p.c. Pref. ...	9½	—	—	—	—	—
8	All	Reuter's (Lim) ...	—	—	—	—	—	acc 10½
Stk.	100	Submarine	220	—	—	—	—	—
1	All	Do. Scrip	—	—	—	—	—	—
10	All	W.India &Pan.(1).	2½	—	2⅜ 5-16 ⅜	—	2 5-16	2 3-16
10	All	Do.6 p. c. 1st Pref.	8⅜	—	—	2 3-16¼ 5-16	—	—
10	All	Do. 2nd Pref.	—	—	—	8 11-16 ⅝	—	8½
20	All	*West. & Braz.(1)	—	—	—	—	—	acc 4⅜ ½
100	All	Do. 6 p. c. Deb., A	—	—	98	—	—	—
100	All	Do. 6 p. c. Deb., B	—	—	—	—	—	—
$1000	All	W.Un. of U.S.7 p. c. 1 Mt. (Bg)Bds.	—	—	—	—	—	—
100	All	Do.6 p. c.St. Bds.	—	—	—	—	—	—

(a) Deferred receiving no div., until 6 p. c. has been paid Preferred.

Remark.—In accordance with the expressed wishes of shareholders, this list will in future be made more complete, and will include all statistics which will be of use to shareholders in estimating the value of their property, such as the amount of stock, dividends last paid, when paid, &c.

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NOTES.

"The Electrician."—The pioneers in scientific telegraphy were worthily represented in the pages of the original *Electrician*. Many who have promised to assist us speak of the memories recalled by our title. It is evident that the efforts then made to adequately represent the science are fully appreciated. We believe, then, our readers will be glad to learn that we use the title with the consent and good wishes of Harry Lobb, Esq., the proprietor of the late *Electrician*. Mr. Lobb still takes a very great interest in the progress of electrical science, and has promised to contribute to our pages. The Editor of the original *Electrician* is a gentleman to whom we owe much of our knowledge of electrical science. His work has been extensive, and is not yet fully appreciated. We trust that our pages will contain materials as valuable as the papers that appeared in our forerunner, and that the gentlemen who supported the original paper will gather round us, and give of the store of their experience, ever mindful that they are speaking to long-tried comrades, as well as to those new members whom time has brought into our ranks.

Velocity of Electric Waves.—The velocity of propagation of waves proceeding from electric sparks has been found by M. Moch to amount to 700m. in the first eight centimetres of the wave's course; but it descends to a value less than that of the ordinary velocity of sound after a passage through one metre.

The Microphone.—On Saturday Sir Henry Thompson demonstrated the value of the microphone (the recent invention of Professor Hughes) for discovering the existence of stone in the bladder, however small the particle might be, in operating on a patient, in the presence of Mr. Erichsen, Dr. Yandell (of the United States), Mr. M. B. Hill, Mr. Clover, Mr. B. Browne, and others. By an application of the same method, in the recognition of a bullet or other foreign body, or of diseased bone at the bottom of a deep wound, the microphone may be made equally valuable.

Great Northern Company.—The Great Northern Telegraph Company state that repeated requests having been made for the conversion of "A" share warrants of 100*l.* (ten shares) each into "B" share warrants of 10*l.* (one share) each the company is ready to effect the same on the following conditions :—1. Applications should be made, and the "A" share warrants should be deposited against a receipt, before June 15 next, in Copenhagen, at the company's head offices; Paris, at the Banque de Paris, et des Pays Bas; London, at the company's office, 7, Great Winchester-street-buildings. 2. The new "B" share warrants will be delivered on and after August 1 next, on return of the deposit receipt and a payment of 1*s.* 8*d.* per share to cover expenses.

A New Telegraph Tariff.—Amongst the proposals which the Government of India are desirous of having brought forward at the Telegraph Conference which is to be held in London next year is one which relates to the substitution of a letter for a word tariff. This, with other proposals, has been communicated to the Indo-European and other telegraph companies, who are decidedly opposed to it. It is objected that a letter tariff would result in serious loss of revenue to the companies, and that it would lead to a system of letter code and packing which would defy every tariff that it would be possible to impose, and ruin the companies for a series of years until they learned to overcome the difficulty. In fact, with their present experience, the companies do not desire to receive single letter telegrams at any price.

Electric Lamp.—A new electric lamp, with incandescence acting in free air, has been described to the French Academy by M. Regnier. A thin rod of carbon, pressed laterally by an electric contact, and forced in the direction of its axis on a fixed contact, is traversed between these two contacts by a pretty powerful current, and becomes incandescent in this part, burning and thinning towards the extremity. As the end gets used up, the rod continually pushed on, slips in the elastic contact, and is thus kept up against the fixed contact. The heat developed by passage of the current in the rod is greatly increased by the combustion of the carbon. An apparatus made on this principle is said to give a clear white light with four Bunsen elements. With a more powerful battery several lamps on this system may be lit.

Progress in America.—As an illustration of how far America is ahead of us in the practical application of telegraphy, we may mention that we have seen petty places in the backwoods, which had no railway within whole counties of them, no coach, no inn, and only, perhaps, a single store, which were, nevertheless, not without telegraph offices. English hamlets of the same size could only owe such a convenience to the squire's being a connection of the Postmaster-General. But American telegraphists consider that, if a town is small to-day, it may be big to-morrow; besides, there is a keen competition to establish branch wires, which may act as feeders for the main lines of communication. So the farmers all along the route undertake to have poles cut and laid ready at equal distances; the companies put up the wires; and there seldom fails to be a sharp youth or damsel in the neighbourhood, who either has or will soon have learned to work the instrument, and will attend to the office for a liberal commission on each message. This is how you often come upon the wires running through the woods in places that do not even boast of a decent road.

The Electric Light.—In the spinning mill of Troullier and Adhemar in Epinal (we learn from the *Bulletin de Mulhouse)*, the system of electric lighting has been adopted. One-half of a large hall of 2,646 sq.m. is thus lit with four electric lamps in place of 60 gas flames; the other portion will be lit in the same way shortly. The lamps now used have been in action three months, and the results are highly satisfactory. The light is inclosed in bells of ground glass, at a height of 3·3m. above the ground. The workmen have no complaints to make about fatigue from the bright light, but prefer the light to gas. The shadows cast by pillars, belts, &c., are not troublesome, because the light rays cross each other, and are largely reflected by the whitewashed roof and walls. The light burns quite regularly; interruptions are very rare, and never occur in all the lamps simultaneously. According to Heilmann and Schneider's experiments, the four lamps would correspond to at least 320 gas flames. The light is produced by means of the excess power only of a hydraulic motor; this makes the arrangement very economical. The electric light, further, does not cause the workmen inconvenience through heat, whereas the former gas system sometimes soon rendered stoppage of work a necessity.

Electric Conductivity and Electrolysis. — Dr. L. Bleekrode has made a large number of experiments to determine the part played by hydrogen in electric conductivity because of its chemical character. These experiments are fully described in the *Phil. Mag.* for May and June, and the result appears to be that no definite law has been found. Still the hydracids, excepting hydrocyanic acid, are bad conductors; their electrolysis is far from proved; their chemical properties in the liquefied state are very feeble, but this

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may result because of their slight solvent power. On the other hand, the organo-metallic radicals and some haloid compounds of the alcohol-radicals readily exchange their metal or hydrogen, and yet are bad conductors. No compound, however, not containing a metal or hydrogen is known as a conductor, and there do not appear to be any substances that are good conductors without being readily decomposed by chemical reactions. F. Kohlrausch and C. Wiedemann, from the results of their experiments, state that not a single liquid is known, which at ordinary temperature is by itself a good conducting electrolyte. Dr. Bleekrode, however, points out liquid ammonia and hydrocyanic acid as substances decomposed even by moderate galvanic currents. It may be remarked that F. Kohlrausch reckoned hydrocyanic acid and ammonia *in solution* as among the worst conductors, and Dr. Bleekrode found them in the *condensed state* to be very good conductors and electrolytes.

Prof. Joseph Henry.—We regret to notice the death of Professor Joseph Henry, at Washington, U.S.A., in his 80th year. He was well known as Secretary to the Smithsonian Institution, and President of the National Academy of Science, was a man of original genius, who at an early age and in spite of educational disadvantages became known by his discoveries in electricity and magnetism. So early as 1831 he exhibited a contrivance for giving signals at a distance by means of a bell arrangement. Little more than the idea of a telegraphic alphabet was wanting to give him a claim on the honours of Morse. In 1832 he became Professor of Natural History at Princeton, and in 1871 he was made head of the Lighthouse board. His papers in the leading American scientific publications have been collected under the title of 'Contributions to Electricity and Magnetism.'

Experiment for Illustrating the Terrestrial Electrical Currents.—The following experiment enables a lecturer to exhibit to a large audience, in a very simple way, the action of the currents of electricity that pass around the earth. A rectangular frame made of light poplar wood, of section three by two centimetres, with sides in length a fraction over a metre, and in breadth three-fourths of a metre. About the perimeter of this rectangular frame wrap twenty coils of insulated copper wire; each extremity of the wire, terminating near the centre of one of the shorter sides, and passing through the wooden frame, is fastened and cut off about three centimetres from the frame. This rectangular frame is then so suspended, in a horizontal position, by wires attached to the frame of an ordinary hydrostatic balance, that the longer sides are at right angles with the beam. By adjusting weights in the pans the index of the balance can be brought to the zero-point. Two small orifices bored in a block of wood, a centimetre apart, serve as mercury-cups, in which the extremities of the short terminal wires are immersed. Near the bottom and through the walls of these wooden cups are screwed small brass hooks, which serve as connections, to which the wires of the battery are attached. The balance is now so placed that the longer sides of the suspended rectangle are at *right angles with the magnetic meridian* or in the *magnetic* east-and-west line. When the current from the battery is made to pass around the rectangle from east to west on the northern side, and from west to east on the southern side, by the theory of terrestrial magnetism the northern side of the rectangle would be attracted and the southern side repelled; and that this is so, the corresponding deflection of the balance renders plainly visible. When the current is reversed the deflection is in the opposite direction. By breaking and closing the circuit at proper intervals to augment the oscillations, the large frame is readily made to oscillate through an arc of five degrees. When the sides of the rectangle are placed north-east and south-west the current produces no sensible effect. A bichromate-of-potash battery of sixteen cells, with plates of zinc and carbon twenty-five by six centimetres, is used. With a rectangle containing a larger number of coils of wire, attached to a very delicate balance, by using a *constantly acting* battery, the variation in the magnetism of the earth might be advantageously observed.

Does the Microphone Magnify Sound?—Mr. Seabroke, in a letter to *Nature*, speaking of experiments he has made with the microphone, says:—"I have chiefly used the instrument that consists of a rod of charcoal, pointed at both ends, supported in a vertical position, with its lower point resting in a hollow in a similar piece of charcoal, while its upper end rests against the sides of a similar hollow above. This form is extremely sensitive, and it is difficult to prevent the circuit being broken while having it sufficiently near the source of sound to be reproduced; the sound of a musical box is perfectly rendered when so far away that there is an absence of jarring from breaks in the circuit; but, in talking to the instrument, any rise in the voice breaks contact, and produces the jarring sound in the telephone, to the exclusion of all articulation. I find that any sort of charcoal or carbon will answer, whether soaked with mercury or not; I therefore conclude that the mercury has little or nothing to do with the action. I have tried the effect of sound on rods of carbon and charcoal, both saturated with mercury, and not so saturated, so arranged that the vibrations could not alter the area of contact, and have obtained no sound whatever from the telephone in the circuit; I therefore conclude that the action takes place at the point or points of contact, and is due to the change of conducting area. To Professor Hughes is due the credit of inventing a means of varying the electric current with extreme rapidity and slight motion without absolutely breaking the circuit; but I doubt whether a microphone is a proper term for describing the instrument. In gently brushing the stand of the instrument sound is heard in the telephone, but it does not at all follow that what we hear is a magnified reproduction of the brushing sound; for, if the rapidity of the vibrations or motion produced by brushing is insufficient to produce sound, still they may move the charcoal sufficiently to produce alternations of current, each of which may be able to set up vibrations in the telephone plate in its own period, or a modification of it, giving what I call the jarring sound. If, therefore, we have this sound, we know that either the microphone is exposed to sounds so loud as to produce complete break of contact or that there is a motion going on affecting it of insufficient rapidity to be audible. With the object of reproducing the voice or musical notes I have made the following modification of the instrument:—A ferrotype plate 3 inches in diameter is fastened over a hole $2\frac{1}{2}$ inches in diameter in a thick piece of wood; a flat piece of gas carbon, weighing a few grains, and having a fine copper wire attached to it, is fastened to the top of the plate in the centre; over the piece of carbon is suspended by a wire spring another piece of carbon finely pointed, weighing about $\frac{1}{4}$oz., and adjusted so as just to touch the carbon plate. The current is then led by the wires through the carbon point, and by careful adjustment of the latter almost any degree of sensitiveness can be attained. Whenever the sound become too loud the current is broken, and minute sparks are seen at the carbon point, and the jarring sound is heard at the same time in the telephone. The sound of a musical box is perfectly reproduced when the box is held in the air; the instrument is, therefore, sensible to sound waves in air as in solids"

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ELECTRODYNAMIC QUALITIES OF METALS.—EFFECTS OF STRESS. By Sir WILLIAM THOMSON, F.R.S., Professor of Natural Philosophy in the University of Glasgow.*

In the first series of experiments described in this paper, the amount of the magnetising force is varied through a range of values from zero to 900, on a scale on which about 12½ is the value of the vertical component of the terrestrial magnetic force at Glasgow, and the effects of hanging on and taking off weights of 7 lbs., 14 lbs., and 21 lbs.,† in changing the induced magnetism, are observed. The experiments were made at ordinary atmospheric temperatures, and at temperature 100° C. The results are shown in curves, of which the abscissæ represent the magnetising forces and other ordinates, the change of magnetism produced by "ons" and "offs" of the weight while the magnetising force is kept constant. The Villari critical value was found to differ for the two temperatures, and for different weights, thus approximately:—

Amount of weight "on" and "off."	Magnetizing force for which the "on" and "off" produce no change of magnetism.	
	Atmospheric temperature (being about 15° C.)	At temperature 100° C.
7 lbs.	266	280 or 290
14 "	231	286
21 "	288	310

The maximum effect of the "on" and "off" was found in each case with magnetizing force of from 50 to 60 of the arbitrary scale divisions (or about four times the Glasgow vertical force). Its amount differed notably, though not greatly, with the temperature, and, as was to be expected, greatly with the different amounts of pull; but it was not nearly three times as much with 21lbs. as with 7lbs.; thus approximately:—

Amount of weight "on" and "off."	Maximum effect in the way of augmentation of magnetism by "on" and diminution by "off."	
	Temperature about 15° C.	Temperature 100° C.
7 lbs.	31 scale divisions of ballistic galvanometer.	25 scale divisions.
14 "	35 do. do.	32·4 do. do.
21 "	54 do. do.	50·3 do. do.

The curves all tend to asymptotes parallel to the line of abscissæ on its negative side for infinite magnetising forces; and they indicate the following ultimate values for the two temperatures, and the different amounts of pull:—

Amount of weight "on" and "off."	Effect in the way of diminution of magnetism by "on" and augmentation by "off" when the magnetizing force is very great.	
	Temperature 15° C.	Temperature 100° C.
7 lbs.	6 scale divisions of ballistic galvanometer.	3 scale divisions.
14 "	13·5 do. do.	9·2 do. do.
21 "	21 do. do.	15·2 do. do.

Later experiments on the effects of pull transverse to the direction of magnetisation showed correspondingly *opposite* effects to those of longitudinal pull, but with a "critical value" of magnetizing force nearly twice as great. That for longitudinal pull, according to the preceding figures, was about 23 times the Glasgow vertical force; for the transverse pull the critical value found was about 60 times the Glasgow vertical force. The transverse pull was produced by water pressure in the interior of a gun-barrel applied by a piston and lever at one end. Thus a pressure of about 1,000lbs. per square inch, applied and removed at pleasure, gave effects on the magnetism induced in the vertical gun-barrel by the vertical component of the terrestrial magnetic force, and, again, by an electric current through a coil of insulated copper wire round the gun-barrel, which were witnessed by the audience. When the force magnetizing the gun-barrel was anything less than about sixty times the Glasgow vertical force, the magnetization was found to be less with the pressure on than off. When the magnetizing force exceeded that critical value, the magnetization was *greater* with the pressure on than off. The residual (retained) magnetism was always less with the pressure on than off (after ten or a dozen "*ons*" and "offs" of the pressure to shake out as much of the magnetization as was so loosely held as to be shaken out by this agitation).

The vertical component of the terrestrial magnetic force at Glasgow is about ·43 c.-g.-s. units. Hence the critical values of the magnetizing force for longitudinal and transverse pull are approximately 10 and 25 c.-g.-s. units. With any magnetizing force between these limits the effect of pull whether transverse or longitudinal must be to diminish the magnetization. Hence it is to be inferred that equal pull in all directions would diminish, and equal positive pressure in all directions would increase, the magetization under the influence of force between these critical values, and through some range above and below them; and not improbably for all amounts, however large or small, of the magnetizing force; but further experiment is necessary to answer this question.

The opposite effects of longitudinal and transverse pull, for magnetizing forces not between the critical range of from 10 to 25 c.-g.-s. units, show an aeolotropic magnetic susceptibility in iron under aeolotropic stress [that is, any stress other than pressure (whether positive or negative) equal in all directions]. Consideration of the relation of this result to Wiedemann's remarkable discovery of the induction of longitudinal magnetization, by twisting an iron wire through which an electric current is maintained, is important and suggestive. In the present paper counter-influence is pointed out, in the aeolotropic change of electric conductivity probably produced in the iron by stress. This influence illustrated by experiments made a few days ago by the author, by Mr. Macfarlane, in Glasgow, and Mr. Bottomley, in the Physical Laboratory of King's College, London, by kind permission of Professor Adams, which shows in two very different ways that twisting a brass tube through which a current of electricity is maintained gives to the electric stream lines a spirality of opposite name to that which the twist gives to longitudinal filaments of the substance, and so proves that in aeolotropically stressed brass the electric conductivity is greatest and least in the directions of greatest and least pressure. The same law probably holds for iron. Wiedemann's result is that the end of the iron wire by which the current enters becomes a true north or a true south pole, according as the twist is that of a right-handed or of a left-handed screw. This is the same direction of effect as would result from the aeolotropy of the magnetic susceptibility produced by the stress of the tangential magnetizing force in the outer part of the wire it is less than the critical value, for which the effect of the stress is isotropic; but it is opposite to the effect due to the aelotropy of the electric conductivity. Yet the author in repeating Wiedemann's experiments has found his result—the same in direction, and greatest in amount—with the strongest currents he has hitherto applied—currents strong enough to heat the wire seriously (but not yet measured or estimated in absolute measure). The reconciliation of the Wiedemann result with the conflicting influence of conductive aeolotropy and with the influence of aeolotropy of magnetic susceptibility, which also is conflicting when the magnetizing force is great enough, is a difficulty which calls for investigation.

The paper includes a series of experiments on the effects of twist on magnetization of iron wire under longitudinal magnetizing force (the Glasgow vertical force alone in this first series). Results of previous experimenters, Matteucci, Wertheim, and Edward Becquerel, according to which twist in either direction diminishes the magnetization are noticed and extended to wires under different amounts of longitudinal pull. When the pull was great, approaching the limit of elasticity of the wire, the twist, even when well within the limits of elasticity, had much less effect in diminishing the magnetism than when the pull was small. The results show a very remarkable lagging of effect, or residue of influence depending on previous conditions.

The paper concludes with a description of experiments, showing in bars of nickel and cobalt effects of longitudinal pull opposite to those found by Villari for iron with magnetizing force below the critical value—that is to say, the magnetization of the nickel and cobalt was diminished by pull. But this effect came to a maximum, and began to diminish markedly as if towards zero, when the magnetizing force was diminished. Hitherto the critical value, if there is one, has not been reached; but the experiments are being continued to find a reversal of the effect, if it is to be found, with attainable degrees of magnetizing force.

* Abstract of a Paper read before the Royal Society, May 23, 1878.

† The wire was of about 22 Birmingham gauge, weighing, therefore, about 14lbs. per nautical mile. It was so soft that it had experienced a considerable permanent stretch by 21lbs.; it would probably break with 30 or 40lbs. Steel pianoforte wire of same gauge bears about 230lbs.

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DYNAMO-ELECTRIC MACHINES.*

[CONTINUED.]

The Brush and Wallace-Farmer machines were accompanied by lamps or carbon holders, which were thought by their makers to present advantages, if not for all machines, at least to be especially adapted to the requirements of their own; the usual "Serrin" lamp, which is made by M. Breguet for the Gramme machine, did not accompany the latter. The result of experiment, however, quickly established the suitability of the Brush lamp as the source of light from all the machines, and the same lamp, with carbons properly adjusted as to size, was used for the several trials.

This lamp consists of a helix of insulated copper wire, resting upon an insulated plate, upheld by the metallic post. Loosely fitted within the helix is the core, partially supported by the adjustable springs. The rod passes freely through the centre of the core, and has at its lower end a clamp for holding the carbon pencil. A washer of brass surrounds the rod just below the core, and has one edge resting on the lifting finger attached to the latter, while the other edge is overhung by the head of an adjustable screw stop.

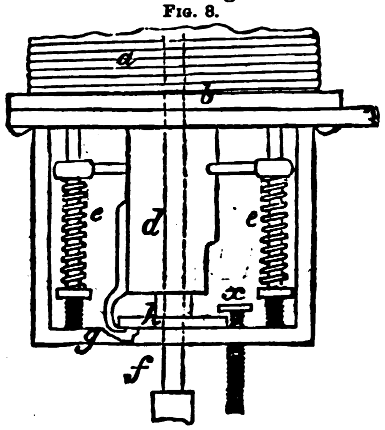
The metal post is supported and guided by a tubular post, secured to a suitable base plate. Attached to the lower end of the post, and passing out through a slot, is an arm supporting an insulated holder for the lower carbon.

If now one conducting wire, from the machine, be connected to the base plate, and the other to the lower carbon holder, the current of electricity will pass up through the posts, and through the helix, rod, and the carbons, thus completing the circuit.

The axial magnetism produced in the helix will draw up the core, and the core, by means of the lifting finger, will raise one edge of the washer, which, by its angular impingement against the rod, clamps and lifts it to a distance controlled by the adjustable stop, but separating the carbon points far enough to produce the light.

As the carbons burn away, the increased length of the electric arc increases its resistance and weakens the magnetism of the helix, and, therefore, the coil, rod, and carbon move downward by the force of gravity, until, by the shortening of the arc, the magnetism of the helix is strengthened and the downward movement arrested. When, however, the downward movement is sufficient to bring the clutch-washer, *h*, to the support, *l*, it will be released from the clamping effect of the lifting finger, and the rod, *f*, will slip through until arrested by the upward movement of the core, due to the increased magnetism of the helix.

Fig. 8.

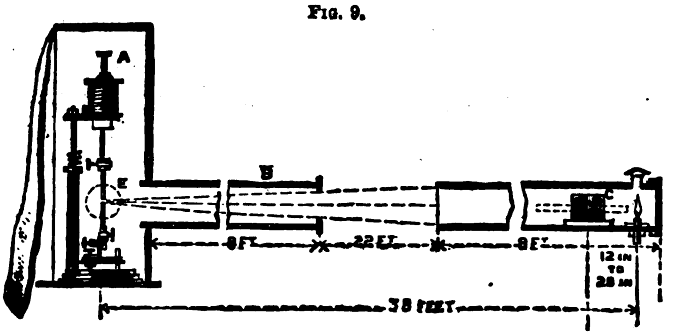


The normal position of the clamp-washer is with the edge under the adjustable stop, just touching the support, *l*, the office of the core being to regulate the slipping of the rod through it. If, however, the rod, from any cause, falls too far, it will instantly and automatically be raised again, as at first, and the carbon points thus continued at the proper distance from each other.

In the lamp used in these experiments, the helix was composed of two separate insulated wires wound together, so that, by means of suitable pin contacts, shown at the top, they could be connected either in couples or end to end, thus varying the intensity of the magnetism of the helix. This, in connection with varying the weight to be lifted by the magnetism of the helix, either by loading the core or increasing the upward thrust of the springs, enabled us to adjust the lamp to suit the varying qualities of the currents dealt with.

In order to make the measurements as accurate as possible, it was found necessary so to arrange the apparatus that no reflected or diffused light should fall on the photometer, and thus introduce an element of error. The arrangement of the apparatus to accomplish this is shown in Fig. 9. The electric lamp was enclosed in a box, open at the back for convenience of access, but closed with a non-reflecting and opaque screen during the experiments. Projecting from a hole in the front of the box was a wooden tube, *b*, 6″ square inside and 8′ long, with its inner surface blackened to prevent reflection, thus allowing only a small beam of direct light to leave the box. This beam of light passed into a similar wooden tube, *c*, placed at a proper distance from the first, and holding in its farther end the standard candle, *d*.

Fig. 9.



This tube also held the dark box of a Bunsen photometer mounted on a slide, so as to be easily adjusted at the proper distance between the two sources of light. A slit in the side of the tube enabled the observer to see the diaphragm. The outer end of the second tube was also covered with a non-reflecting hood, and the room was, of course, darkened when photometric measurements were taken. The rigid exclusion of all reflected or diffused light is believed to be the only trustworthy method of obtaining true results, and will, no doubt, account in a large measure for the lower candle-power obtained by these experiments than that obtained by many previous experiments.

The difficulties encountered in the measurement of the light arising from the difference in colour were at first thought to be considerable, but further practice and experience enabled the observer to overcome them to such an extent that the error arising from this cause is inconsiderable, being greatly less than that due to the fluctuations of the electric arc.

The advantage to be derived from using a larger source of light than the standard candle, in measuring the electric light, was considered. A gas-flame, giving 20 candles' light, and the oxy-hydrogen light, so adjusted as to give 70 to 136 candles, were carefully measured and used as a comparison. Both of these were found unsatisfactory, and the measurements relied on for our calculations were made entirely with a standard candle, carefully corrected for any variation of consumption from 120 grains per hour.

Were much higher intensities of light to be measured, it would be well to use, as a means of comparison, a large gas-burner or a multiple-wick lamp, such as are employed in lighthouse service, its power being constantly checked by measurements with the standard candle and separate photometer; but, with the volume of light dealt with in these experiments, the candle was sufficiently large, and its direct use greatly reduced the chance of error.

In the earlier experiments, measurements of light, current, and power were made simultaneously, thus establishing standard references by which after-experiments upon the different points were connected.

In determining the amount of light produced by each machine, it was run continuously for from four to five hours, and observations made at intervals, care being taken to maintain the speed and other conditions normal. One of the most important conditions necessary to insure correct results was the relative position of the carbon points. Great care was taken that the axes of the two sticks or pencils of carbon were in the same line, so that the light produced should be projected equally in all directions. Were the axes of the carbon pencils not in the same line, a much greater quantity of light would be projected in one direction, and the result of calculation of the light produced, based on the inverse square of the distance from the photometer, would be too great or too small, according as this adjustment was in the one on the other direction.

To facilitate observations during the experiments, there was attached, at *e*, to the side of the box *a* holding the electric lamp, a focussing lens, with its axis at right angles to the beam of light, to the photometer, and an image projected upon a screen enabling the observer to see the condition and position of the carbon points without fatiguing the eye. Photographs were also taken, from time to time, at the moment of making the photometric observations—thus securing a permanent record of the condition of the carbon points.

* Report to the Franklin Institute of Messrs. Briggs, Professors Rogers and Chase (Photometry), Professors Houston and Thompson (Elect. Meas.), and Messrs. Jones, Sartain, and Knight (Dynamical Meas.).

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Another difficulty in determining the exact photometric value of the electic light is the fluctuation, or rather the moving from side to side, of the electric arc, and great care was taken so to adjust the conditions that the arc or flame should be steady and equally distributed about the ends of the carbon pencils.

FIG. 10. FIG. 11. FIG. 12. FIG. 13.

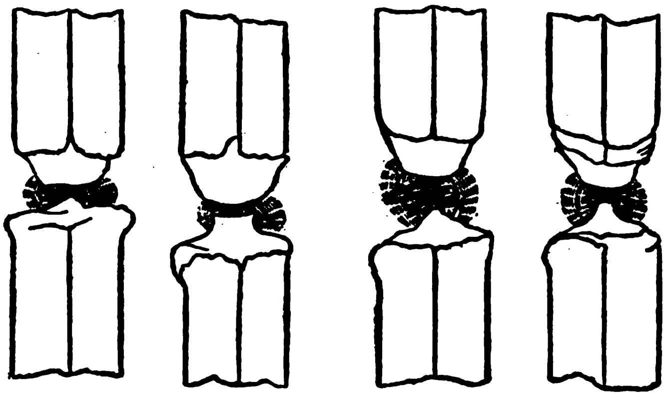
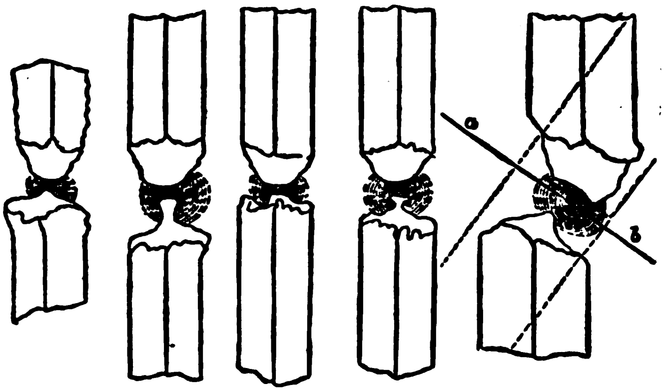


FIG. 14. FIG. 15. FIG. 16. FIG. 17. FIG. 18.



Figs. 10 to 18 are full size, exact reproductions of the photographs taken, and fairly represent the average condition of the carbon when observations were made.

It was found that although there was a slow consumption of the negative carbon there was, at the same time, a constant "stalagmitic" growth of particles carried from the positive carbon by the action of the electric current. These stalagmites assumed different forms, as shown in the cuts, but no particular form seemed to be produced by the current from the different machines, except that the deposits on the negative carbon would become greater with increased current. These deposits would build up gradually until they had assumed the forms shown in Figs. 18 and 20; then growing narrower near the base, until, by a weakening of the current by this and the consumption of the upper carbon, the latter would readjust itself, and the piece would drop off. The effect of these growths on the intensity of the light was scarcely appreciable, except for a few seconds before and after the readjustment of the lamp.

[TO BE CONTINUED.]

PROFESSOR CLERK MAXWELL ON THE TELEPHONE.

[CONCLUDED.]

It was reserved for Professor Bell to discover that the vibration of a tinned iron plate, set in motion by the voice, would produce such currents in the circuit as to set in motion a similar tinned plate at the other end of the line. It will help us to appreciate the fertility of that germ of science which Faraday first detected and developed, if we recollect that year after year he had employed powerful batteries and magnets and delicate galvanometers to obtain evidence of what he all along hoped to discover, the production of a current in one circuit by a current in another; but all without success, till at last he detected the induced current as a transient phenomenon, to be observed only at the instant of making or breaking the primary current. In less than half a century, and by the aid of no second Faraday, but in the course of the ordinary growth of scientific principles, this germ, so barely caught by Faraday, has developed, on the one hand, into the powerful currents which maintain the illumination of the lighthouses on our coasts, and, on the other, into these currents of the telephone, which produce an audible effect, though the engine that drives them is itself driven by the tremors of a child's voice. Professor Pack has recently measured the absolute strength of these telephone currents. He produced them by means of a tuning-fork vibrating in front of the coil of the transmitter. Before the transmitted note ceased to be audible at the other end of the line, he measured by means of a microscope the amplitude of the vibrations of the fork. He then placed a very delicate galvanometer in the circuit, and found what deflexion was produced by a measured motion of the fork. Finally, he measured the deflexion of the galvanometer produced by a small electro motive force of known magnitude. He thus found that the telephone currents produced an audible effect when reversed 500 times a second, though their strength was no greater than what a Grove's cell would send through a million negatives, or about a thousand million times less than the currents used in ordinary telegraphic work. One great beauty of Professor Bell's invention is that the instruments at the two ends of the line are precisely alike. When the tin-plate of the transmitter approaches the core of its bobbin it produces a current in the circuit which has also to circulate round the bobbin of the receiver, and thus the core of the receiver is rendered more or less magnetic, and attracts its tin-plates with greater or smaller force. Thus the tin plate of the receiver reproduces on a smaller scale, but with perfect fidelity, every motion of the tin plate of the transmitter. This perfect symmetry of the whole apparatus—the wire in the middle, the two telephones at the ends of the wire, and the two gossips at the ends of the telephones—may be very fascinating to a mere mathematician, but it would not satisfy an evolutionist of the Spencerian type, who would consider anything with both ends alike, such as Mr. Bright's terrier, or Mr. Bell's telephone, to be an organism of a very low type, which must have its functions differentiated before any satisfactory integration can take place.

Accordingly, many attempts have been made by differentiating the function of the transmitter from that of the receiver to overcome the principal limitation to the power of the telephone. As long as the human voice is the sole motive power of the apparatus, it is manifest that what is heard at one end must be fainter than what is spoken at the other. But, if the vibration set up by the voice is used no longer as the source of energy, but merely as the means of modulating the strength of a current supplied by a voltaic battery, then there will be no limitation of the intensity of the resulting sound; so that what is whispered to the transmitter may be proclaimed *ore rotundo* by the receiver. A result of this kind has been obtained by Mr. Edison by means of a transmitter, in which the sound vibrations produce a varying pressure on a piece of carbon, which forms part of the electric circuit. The greater the pressure the smaller is the resistance due to the insertion of the carbon, and therefore the greater is the current in the circuit. I have not yet seen Mr. Edison's transmitter, but the microphone of Professor Hughes is an application of carbon and other substances to the construction of a transmitter, which modulates the intensity of a battery current in more or less complete accordance with the sound-vibrations it receives. The energy of the sound produced is no longer limited by that of the original sound. All that the original sound does is to draw supplies of energy from the battery, so that a very feeble sound may give rise to a considerable effect. Thus, when a fly walks over the table of the microphone, the sound of his tramp may be heard miles off; indeed, the microphone seems to open up several new lines of research. We shall have London physicians performing stethoscopic auscultations on patients in all parts of the kingdom. The Entomological Society have recently been much interested by Mr. Wood-Mason's discovery of a stridulating apparatus in scorpions. Perhaps, ere long, a microphone placed in a nest of tropical scorpions may be connected up to a receiver in the apartments of the Society, so as to give the members and their musical friends an opportunity of deciding whether the musical taste of the scorpion resembles that of the nightingale or that of the cat. I have said the telephone is an instance of the benefit to be derived from the cross fertilisation of the sciences. Now, this is an operation which cannot be performed by merely collecting treatises on the different sciences and binding them up into an encyclopædia. Science exists only in the mind, and the union of the sciences can take place only in a living person. Professor Graham Bell, the inventor of the telephone, is not an electrician who has found out how to make a tin-plate speak, but a speaker who, to gain his private ends, has become an electrician. He is the son of a very remarkable man, Alexander Melville Bell, author of a book called "Visible Speech" and of other works relating to pronunciation. In fact, his whole life has been emloyed in teaching people to speak.

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TELEGRAPH ROUTES TO INDIA.

HERODOTUS, who also records the fire-signals by which the Athenians communicated with their fleet, is constrained to declare his admiration of the system of express-posts established by the Persians. "Nothing among mortals advances more rapidly to its destination," he says, describing how the couriers of "*the* King" rode night and day over the plains of Phrygia and Cappadocia, the steep mountain passes of Cilicia, the streams of Mesopotamia, speeding along a chain of roads, duly provided with inns, relays, ferries, guards, and all other conveniences of ancient travel, till they reached the capital of the Medic Empire with a celerity that must have seemed worthy of better news than had to be borne from the fields of Marathon and Platæa. What would the Father of History think, could he come to know that the fullest and most accurate signals can now be flashed from furthest India to regions then unknown in as many minutes as it took months to communicate between Sardis and Susa! And his astonishment would be none the less to learn that the main difficulties over which this wondrous triumph of science has been gained were met with in the very region to which his world would have looked for a master-piece of civilized ingenuity. It is the countries of the Great King which are now given over to backwardness and fatuity; and the present despot of Persia is at this moment travelling in far other guise than Cyrus and Xerxes, hoping to learn or perhaps to beg something from us once romote barbarians who, as his predecessor vainly thought to do, have veritably cast our chains upon the ocean and lashed its rebellious straits to some purpose with gutta percha cables.

It was the outbreak of the Indian Mutiny which urged on us the desirability of a complete telegraphic communication with our Eastern empire. The history of this great undertaking is now written in Sir Frederick Goldsmid's "Telegraph and Travel," in Mr. J. C. Parkinson's "Ocean Route to India," in the Reports of Parliamentary Committees, and concisely in Major Bateman-Champain's paper on "Telegraph Routes between England and India," read at a recent meeting of the Society of Arts. The task was not to be done in a day, nor at the first attempt; there were failures and disappointments, and more than one brave man's life had to be sacrificed to the adverse powers of these sterile regions across which the slender wires must be stretched for the first time. The dangers and difficulties must have, indeed, seemed overwhelming at an early stage of the enterprise. Not only were physical obstacles to be conquered and guarded against, but the supineness, the corruptness, and crass stupidity of Eastern officials, the rapacity of wandering Arabs who, like some white Christians, thought little sin of robbing a telegraph company, the mischievous habits of peasants far enough advanced in civilization to carrry guns, but too ignorant to understand that telegraph posts and insulators were not set up as targets for the Faithful, while their scarcely more enlightened superiors were only by fits and starts ready with the bastinado, which is the sole form of reasoning to impress a due respect for science on these people. Such was the experience of those who had to lay the aerial line through Asia Minor and Persia to Bushire. Nor were there no risks in view for the next experimenters, who, going by the ancient precept, *ariston men hudor*, had to contend with the coral reefs and irregular soundings of the Red Sea, at a time when submarine telegraphy had as yet gained little trust in its resources. But by patience and skill all these difficulties were overcome; experience has proved some of the threatened dangers to be fictitious or exaggerated; and the wonder now is that more frequent and serious stoppages do not occur in working over desert and ocean this magic undreamt of by Haroun Alraschid. Occasional delays, unavoidable in all the circumstances, are of less importance as we have no longer to depend on one line. There are three main telegraph routes to India—the original Turkish land line to the Persian Gulf, the Indo-European line *viâ* Kertch, Tiflis, and Teheran, and the Eastern Company's cable by Malta and Suez. Two of these, moreover, along the greater part of their lines, have double cables, also power of indirect communication through other wires in case of accident to their own. So, in times of peace, our communication with India may thus be held to be assured, and in three hours, as a rule, a London merchant may give orders to his Eastern correspondent seven or eight thousand miles from Charing-cross. And the Herodotus of the future will note that such great results have been mainly accomplished by private enterprise.

Recent political events have called serious attention to the safety of these important communications under possible circumstances which are so much in the thoughts of all. We intend to deal with this question in another article. Meanwhile we will only point out that there is a growing disposition to treat the maintenance of telegraphs as a matter of cosmopolitan interest. It is satisfactory to learn that we have recently received political telegrams which had passed unhindered through the heart of Russia, though their contents could scarcely have been agreeable to that Power in its present mood. This forbearance, no doubt, has its limits. But it is an auspicious sign for the future, when, as our expectations of the progress of electrical science are unlimited, so are our hopes from its moral influence. The science which has led us to the microphone is bringing on with gigantic strides that day when men shall see how much it is unworthy of them to waste such noble faculties in the barbarous arts of destruction. Every wire between civilised countries is a fresh link in the chain of enlightened friendship. As soon as nations are able rightly to appreciate the true benefits of such a discovery, they must come to see the madness of using the marvellous

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powers of the telegraph for mutual messages of hatred and defiance. So we are justified in declaring to pessimists and politicians that a power is at work which will at no distant date interfere with their short-sighted calculations, and prove itself in the cause of peace a more potent ally than it ever was for war.

ON THE STUDY OF ELECTRICITY AS A PROFESSIONAL PURSUIT.

BY THOMAS T. P. BRUCE WARREN.

About six years ago I had occasion to instruct a large staff of assistants for electrical testing, and, in answer to several inquiries as to the best works for reading up the subject, I felt the reality of a great gap in this department of the science of telegraphy, and I was compelled to adopt a systematic course, advising the perusal of books only in cases where it was attempted to become more than an expert tester.

Since that time the literature of the science has been somewhat enriched by many contributors. The most important step was the publication of a little volume by Capt. Hoskier, of Copenhagen, for the instruction of the staff of electricians and clerks in the employ of the Great Northern Telegraph Company. More recently we have the subject handled from two separate points of departure by the text books of science published by Messrs. Longmans. The volume by Messrs. W. H. Preece and Sievewright deals more especially with the commercial portion of the subject, whilst that by Professor Fleeming Jenkin brings the scientific department so thoroughly in harmony with the practical requirements of the present advanced state of knowledge, that the difficulty of advising a student what books to read so as to make a fair electrician is to a very great extent removed.

There still appears, however, an important hiatus, which the generality of electricians either have not felt or have allowed to drop out of sight, either from a want of inclination to deal with the minutiæ which are picked up by practice, or from a notion that hints gathered in practice, cannot be well conveyed. Frequently, however, a little piece of information in the way of instruction or hint, though apparently trivial when noted, has received an unforeseen importance when too late.

I shall endeavour in these papers to deal with the duties and qualities of an electrician, and to treat of such portions of the science as have received a practical development. It is necessary to say a few words on the character and capabilities of anyone wishing to become an electrician, for I know from experience that a short time ago many young men had an idea that the knowledge of electrical work was to be picked up in a few weeks, and that the acquisition of this knowledge was to secure, when an appointment was obtained, the Eldorado of a "gentlemanly occupation." An advertisement being inserted in *The Times* for a few assistants in an electrician's office, there was in the replies to it this extraordinary omission, that not a single applicant had the least knowledge of electrical work; the applicants were either those in search of a "gentlemanly employment," or others looking out for more remunerative work, and among them schoolmasters, War-office clerks, &c. To all those who were already in situations I gave the advice to remain where they were. In less than two months not a single applicant to the advertisements remained at the work. One, the son of a clergyman, I recollect, took objection to the work because cables were likely to be paid out on Sundays. Many considered the work tedious and monotonous, and others took a decided dislike to the night duties.

My experience of electrical work, and I believe everyone who earnestly goes in for the profession of an electrician will feel the same, is that it is a profession which requires great sacrifice of comfort and personal convenience, and is by no means fit to be called a light and easy employment. No humane parent would think of putting his son to learn a business or profession for which he is physically or mentally unfit. An electrician or telegraph engineer has sometimes such a burden of responsibility hanging upon an individual action, as would absolutely scare one with tolerable ability if not well fortified with nerve and determination. Cases have happened over and over again in paying out submarine cables where the loss of time due to hesitation or uncertainty would have been followed by serious consequences. So a well ordered mind is the *sine quâ non* of an Electrician. To be well acquainted with every method of testing, and to be expert in applying any test when things are going on well, are simple acquirements, but to be ready without a moment's hesitation to arrange for any particular test on board ship with a cable still running out, or perhaps hanging over the stern with the ship kept to, is, I believe, a circumstance, even to men of tolerable experience, a severe trial. An Electrician should not only instruct his staff, in the duties that have to be performed, but he should instil into them a notion that all knowledge without confidence is of little value. Perfect confidence and reliance should be felt, and should be supported by every possible sentiment of good feeling. An Electrician can then feel that every member of his staff will be actuated by motives dictated by the highest sense of duty to do his best in any or every emergency. Mistrust is a word which should not be heard in a testing room. An assistant who cannot secure the absolute confidence of his chief is not fit for the higher duties of the profession. An amiable disposition is a great recommendation in a young man; an irritable or morose temper would be a damaging quality. I have found that young men of very studious habits are by no means likely to become very accomplished electricians; individuals of an ingenious turn of mind require to be carefully watched. I have heard of cases where ingenuity has devised some terribly perplexing freaks of awkwardness and mischief. Some years ago, before galvanometers were brought to their present state of perfection, it was possible only to test india-rubber covered wires with electrometers. In the form of instrument which I used, the suspension of the pith balls and reed was a very fine glass thread. During my absence some ingenious person replaced the glass thread with a very fine human hair. This was discovered by adjusting the instrument in an ordinary dry room, and then removing it to the tank house to test a few short pieces of wire. The reed could not be made to return to zero as before, which led to the examination of the fibre. The hyposcopic quality of the hair never entered the brain of the ingenious party. Another instance with a similar instrument may be given as showing what mischief or ill feeling may be led to do. The individual who devised the trick related it to me personally. The excitation of the brass balls, which repel the pith balls, was given by a wire communicating with their arms, and which was enclosed for insulation in a well-varnished glass tube. In order to embarrass one using this instrument, ingenuity had passed his finger, moistened with a little sulphuric acid, on the outer surface of the tube, so as to put the brass ball surmounting it in communication with the base of the instrument.

It is sufficient to say that such persons as these should never be allowed to enter a testing room. It further illustrates the necessity of having trustworthy assistants, for it is evident that a malicious or vindictive person may, in an endeavour to give trouble to his companions, involve his employers in some heavy loss for instruments, &c. Practical joking with instruments is a dangerous amusement, and any one who has once been the victim to a trick can never be censured for over-cautiousness.

Young men who have received some kind of commercial training make very good electricians if they have a taste for scientific pursuits. Instrument makers I have found more especially fitted for the work, and become in addition, after a short time, skilful and expert signalling clerks. On foreign stations such young men become of important use when anything goes wrong with either the testing or signalling apparatus. To be handy in the use of mechanical tools is a great recommendation, and I have no doubt the next generation of telegraph clerks will be in this respect a great advancement over the present. As a rule, a young man who can use a soldering iron neatly will be more useful than one whose mathematics will enable him to determine how far above a table a light should be placed so as to illuminate the greatest space possible.

Mathematics is peculiarly a science which trains to thinking, and, although I should be sorry to say one word in disparaging science, I cannot help remarking that I have found young men of ordinary education make more useful and trustworthy assistants than those who have attempted to cram themselves with a knowledge of almost everything in science.

A taste for general reading should be cultivated by everyone; a man accustomed to read nothing but scientific books cannot easily sit down to read a novel. To clerks on foreign stations I would say, that it will be better to let your reading be mixed, so that you may take up a scientific book when you are in the humour for it, or the works of some respectable novelist if you find the time is hanging heavily upon you. Remember that time idly spent may lead to greater evils than "wasting a few hours," as it is called by some people, on novel reading. The atmosphere of a "tap room" will work more mischief on the mind of a young man, who may be many miles from the reach of home influence, than a few hours spent with our best authors. Music, an occasional game at billiards or cards, will all help to make time pass pleasantly, and I cannot see why our telegraph companies do not see that it is better to keep their staff together under one roof than to allow young men, perhaps thoroughly unused to the world, to find their own amusements, or to fill up their spare time as if regardless of their interests.

A case in point occurs to me whilst writing, where a certain

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company has provided a commodious house and grounds, with piano, billiard table, library, &c., for the staff, and I would venture to say that no gentleman in this country could wish to see better regulation in his house than is to be met with here.

Natural history, botany, geology, and mineralogy are all branches of science easily picked up and cost little in their acquisition, and, to anyone who may have made up his mind to visit foreign countries, will afford abundant interest and amusement. From the generally superior mental qualification of the telegraph clerk, I think the whole range of the sciences ought to receive some important additions, considering the facilities at his disposal. Let us simply look at Brazil, and, with all the scientific explorations of Agassiz and others, we must still consider that a great deal is left to be done. Supposing that a little of the money voted by our Government for the endowment of research could be applied to stimulate inquiries on meterological phenomena at the foreign telegraph stations, I believe most of our companies would willingly support such useful and important inquiries.

[TO BE CONTINUED.]

ON THE TARIFF FOR TELEGRAMS PER WORD.

[The question of tariffs is one of such importance, and has been so ably discussed in the organ of the International Convention, the *Journal Télégraphique*, that we intend to reprint the series from its columns.]

Since March 1, 1876, a new tariff has been in force in the telegraphic service in Germany. According to this tariff the charge for a telegram consists of two parts—namely, a fixed charge, irrespective of the length of the telegram—*i.e.*, a principal charge, and a charge applicable to each word of the telegram—*i.e.*, a charge per word.

The new tariff has succeeded in attracting general attention. As for the appreciation of the system itself, it has been generally acknowledged, notably by the Chambers of Commerce in Germany, that it has been a perfect success, and that it is an improvement upon the system formerly in favour of the unit of twenty words with an increase of charge for every additional ten words. The innovation has not failed, however, to provoke some objections, and to become the object of some remarks by respectable authorities. It will, therefore, not appear superfluous for us to examine the results of the tariff per word in Germany, basing our remarks upon the experience acquired up to the present time.

Before approaching the subject itself, we may be permitted to remind our readers briefly and without any profound discussion of the general conditions which a tariff should fulfil in the matter of communications—conditions which have also served as a basis for the adoption of the tariff per word.

In such a question as this there are three principal rules :—

1. The tariff should be fixed in such a manner as that the remuneration claimed by the administration may correspond as exactly as possible with the outlay—*i.e.*, with the expenses of the administration in labour and material. This rule is based on the conviction that the lasting prosperity of services of communication established for the good of the general economic situation will be assured only in so far as the proper end of these institutions regulates their tariffs. The observance of this principle does not allow the working of communications to be treated as lucrative enterprises; but it also excludes considerations of finance and financial economy which would have to be taken into account if the charge were to be measured by the value of the service rendered to the public. We have no wish to ignore the fact that the tendency to accept this last consideration has something tempting about it. It seems such a simple thing to say, "Since, in certain given cases, the service of communications is used only as an organ for interests of great importance, we may fairly in those cases demand a high remuneration, provided the latter remain still insignificant in proportion to the value of the transaction of which it is the intermediary." And yet this conclusion rests on no solid foundation.

2. The tariff should be simple—that is to say, intelligible to all —and easy in its application. Thereby a double advantage will be realized : facility for the administration in levying the charge and in keeping the accounts resulting from it; and the possibility for the public to calculate the charges by themselves and without having recourse to any special aid, and respectively to verify the correctness of the charges made.

3. The tariff should allow the public to derive the greatest possible profit from the resources of the service of communications, without an infringement of the principles of the tariff; in other words, the public should be free to attain the end they have in view by claiming from the service only the smallest possibly outlay; but, on the other hand, they should not be able to increase the outlay of this service without giving a corresponding compensation.

Thus the general interest will be stimulated to increase the whole working capacity of the administration.

Of course, on the one hand, these three rules command one another, and, on the other, mutually limit one another, so that we cannot, in practice, apply any one of them to the exclusion of the others, and that so much the less as there are other conditions of which we have not spoken, which should have equal influence in the formation of tariffs.

The observance of these rules ought before everything to lead necesssarily to the introduction of a low unit of charge for telegrams. The unit of twenty words, with an extra charge for every ten words, adopted in the international traffic, and applied also formerly to the internal traffic in Germany, was too high to be maintained. This minimum considerably exceeded the average of the necessary length of a telegram. The public, naturally, desired to use the whole number of words paid for, and they were thus induced to introduce useless words into their telegrams. The same thing took place in longer telegrams in the case of the additional ten words. On the other hand, the minimum amount of the charge for a unit of twenty words could not be fixed so low as not to prevent the public from making use of the telegraph on account of the amount of the charge, they having only very short communications to send.

If we consider that telegraphy cannot carry out *en bloc* the transmission of correspondence, but that, on the contrary, in spite of all the progress of technical science, it must always produce each signal separately by a special emission of the electric current, and reproduce it by means of the apparatus at the corresponding station, and that consequently the working capabilities of telegraphs are limited and easily exhausted, it follows that the exact measure to apply to the tariff is the number of signs or letters to be transmitted, and that the letter, or respectively the cipher, constitutes the true unit of charge.

Practical considerations, which do not need any further explanation, are opposed to the adoption of the tariff per letter. *Per contra*, the word of a fixed length constitutes the natural unit coming immediately after the letter.

It will be asked, perhaps, if it is really necessary to reduce the unit of charge to *one* word, or if for this unit *two* or *three* words would not be more suitable. But the solution of this question rests upon this fact, that the word is a unit given naturally, whilst, to fix one number of words rather than another, it would be difficult to find a simple principle which should reconcile different and more or less justified individual opinions.

To prove the truth of this assertion, we have only to examine the internal tariffs of European countries. Although the minimum of twenty words has been in use for some time in international correspondence, we find in internal services minimums of charge in Spain for ten words, in Italy and Norway for fifteen words, in England, with address and signature gratis, for twenty words. The same thing is reproduced in the progressive scale of charges. As soon as the changes of tariffs are looked into, new combinations do not fail to arise. Thus, for instance, the Commission of the Swiss *Conseil National* has proposed, in place of the tariff per word now adopted, a tariff with a minimum of fifteen words, and with a progressive increase for every additional ten words. The Lyons *Conseil d'Arrondissement*, in view of the projected change in the French tariff, suggest that addresses should be gratis, but not signatures.

If, then, we consider it as advantageous for a tariff not only that it should be simple in itself, but also (in anticipation of the greatest possible extension) that it should be capable of contributing to the general simplification of tariffs, we must keep to the word as the natural unit. Again, we must remark that the tariff per word is already in use for extra-European correspondence; that since the beginning of the year 1877 this tariff has been in force for messages both ways, between Germany on the one side and Switzerland on the other, as well as for German correspondence destined for Sweden; moreover, that on January 1, 1878, it became applicable to correspondence between Germany and Holland; and, lastly, that it has been adopted by the Swiss legislative bodies for the internal communications of that country.

In Italy and Spain the tariff per word is adopted for telegrams of more than fifteen, or respectively of more than ten words. For the change in the French tariff it is proposed that there should be provisionally a similar combination, without prejudice to the future adoption of a tariff per word.

The tariff per word, since its introduction into Germany, has thus been largely adopted elsewhere.

Besides the charge per word, the German tariff includes also a fixed charge for each telegram. The latter—the principal charge —serves as compensation for the operations necessary for every

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telegram, whatever may be its length, such as the consignation, the remise, the call-signal for transmission, the preliminaries of the service, that is to say, the indications of the service and the gratuitous communication of the place and hour of deposit.

Before entering further into an examination, based on figures, of the results obtained in Germany, we may be allowed to refute one more objection raised against the tariff per word, the value of which could not easily be represented by figures. The simplicity of the tariff per word has been contested by the assertion that the fixing of the charge is more difficult under this system than under the old system of tariffs per so many words, and that, consequently, the working of the taxation and accounts is longer and more complicated. It is difficult to admit *a priori* the justice of this argument. An account of the number of words is necessary for both tariffs. In the case of the tariff per word, the number of words must be multiplied by the amount of the charge; under the old system, for telegrams of more than twenty words, we must first of all determine the number of units or half-units of charges, to calculate (on the basis of the charge for a telegram of twenty words) the total amount levied. It may still be doubtful which of these two methods presents the greater difficulties; in any case, the practical application of the tariff per word does not appear to have caused any inconvenience or complication in the working of taxation and accounts.

The charge for telegrams was formerly, in Germany, fixed on the basis of three zones, determined by the system of *taxquadrats*. The charge for the first zone, for a maximum distance of eighteen miles, was 50 pfennigs; that of the second, for a maximum distance of fifty-two miles, was 1 mark; that of the third zone, including all greater distances, was 1 mark 50 pfennigs for a single telegram of twenty words.

Since March 1, 1876, these charges have been replaced by a uniform tariff, by which, for each telegram, irrespective of distance, a fixed charge is made of 20 pfennigs, and a charge per word of 5 pfennigs.

The number of telegrams subject to the charge which were handed in throughout the telegraphic territory of the German Empire from March 1, 1876, to the end of the same year was 5,812,966.

In the corresponding period of the preceding year the number was 6,150,595, showing a decrease in 1876 of 337,629 telegrams.

Thus the number of telegrams despatched decreased from 1875 to 1876 at the rate of 5·5 per cent.

It cannot, however, be doubted that the chief cause of this decrease was the generally unfavourable state of trade, for the *traffic* with foreign countries decreased in like manner. During the same months the number of "home" telegrams was—in 1875, 1,317,860; in 1876, 1,296,291; showing, in 1876, a decrease of 21,569 telegrams, or 1·7 per cent.

If we consider now that all facts liable to influence the *traffic*, act with much more intensity in the nearest, and therefore the most frequent, relations than in great international relations, we shall be safely able to regard the decrease in the number of telegrams in the "home" service as a consequence of the dulness of trade and the unfavourable state of commerce and industry.

The receipts arising from the charges give, from March to December inclusive: in 1875, 4,968,645 marks—for one telegram, 80 pfennigs; in 1876, 5,406,058 marks—for one telegram, 93 pfennigs.

This shows an increase for the year 1876 of 437,413 marks, or 13 pfennigs per telegram.

The receipts, therefore, increased, on an average, at the rate of 16·3 per cent. for one telegram; and for the whole, notwithstanding the decrease in the number of telegrams, at the rate of 8·8 per cent.

In the receipts for 1876 are included also the charges for "urgent telegrams" which had not been introduced in 1875. It is no longer possible to estimate the influence of this higher charge. In any case we shall estimate its effect rather too high than too low, if we apply to 1876 the results obtained for the current year, which we give below, for the urgent telegrams, like all innovations, have had only a gradual development.

According to the special estimates for 1877, the receipts for this year amount to 86 pfennings for each ordinary telegram.

It follows, then, that in the last ten months of 1876 an average of 7·5 per cent. more was charged for an ordinary telegram than in the corresponding period of 1875. The total receipts for 1876 must therefore be estimated at 5,812,966 × 86 pfennigs = 4,999,150 marks, *i.e*, at 30.505 marks, or about two-thirds per cent. more than the previous year.

The decrease in the number of telegrams in 1876 was only a temporary one.

From January to May there were despatched in 1876 2,751,852 telegrams; in 1877, 2,966,869, giving in 1877, relatively to 1876, an increase of 215,017 telegrams, or 8 per cent.

During the same months of the year 1875, when the old tariff was still in force, there were 2,817,434 telegrams, giving in 1877, relatively to 1875, an increase of 149,385 telegrams, or 5·3 per cent.

The decrease in the number of telegrams in 1876 was thus amply made up for by the increase in 1877.

The receipts, including the charges levied for urgent telegrams, gave for the period already named: in 1876, 2,421,912 marks; in 1877, 2,729,519 marks, showing an increase in 1877 of 307,607 marks, or 12·6 per cent.

The receipts in 1875 having been 2,254,000 marks; the increase from 1875 to 1877 is, therefore, 475,519 marks, or 21·1 per cent.

If we take for the telegrams of 1877—as urgent telegrams were not yet admitted in 1875—the charge for an ordinary telegram (86 pfennigs), we shall obtain for 1877 a sum of 2,551,507 marks, which exceeds the receipts for 1875 by 13·20 per cent.

The result above given may certainly be looked upon as very favourable, more especially if we consider that the former high rates of 1 mark 50 pfennigs and 1 mark for the third and for the second zone are abolished, and that in the zone which was formerly the least expensive, a short telegram (as is actually the case) may be transmitted at the same rate, and even at a lower rate than before.

This last circumstance shows a great advantage possessed by the tariff per word, namely, that of facilitating the simplification of tariffs. We may unhesitatingly assert that the abolition of the old tariff by zones, in Germany, with its scale of charges in the ratios of 1, 2, 3, and the substitution for it of a uniform tariff, could not have been carried out without seriously affecting the interests of the public, if the tariff per word had not been adopted as the basis of the uniform tariff.

To this the following objection has been made:—"Is the uniform tariff a just one in the case of such an extensive territory? as it does not take in account the length of the lines, is it not contrary to the principle that the returns should be in proportion to the outlay?

Although these questions have no necessary correlation with the principle of the system of tariff, we must nevertheless examine them.

The expenditure of Telegraph Companies is represented for each telegram by the two principal kinds of service. Each telegram must have at its disposal the necessary lines, apparatus, and working force; and, secondly, the labours required by the handing-in, the remise, the transmission, and the reception, must all be effected, as well as the intermediate repetitions, in case of need. It must be allowed, it is true, that the former of these services deserves to be in some measure taken into consideration; but only when the expenses necessary for this service form a considerable part of the total expenses, particularly as regards this principal element of the expense of the lines. But this occurs only for transmission in transit, in which case we must in some degree take into account the length of the lines of transmission. As concerns general transmission, distances relatively need not be taken into account.

The handing-in and the remise, the reception and the transmission of telegrams, are in no way dependent upon the length of the line. The number of intermediate receptions, the number of instruments, the consumption of paper, &c., are dependent on the importance of the traffic between the place of departure and the place of destination, and only for very considerable distances (which we may consider as exceptional cases) on the length of the line.

Taking these considerations into account, we may, if we wish to form some approximate idea of the proportion of expense between these two branches of the service, admit the following. The expenses of the staff of the administration serve principally as a remuneration for the labour involved in the transmission of telegrams; they thus represent the share of the general expenses without regard to the length of the lines and the extent of the communications. The expenses of *matériel* must be considered as dependent upon the length of the lines. This distinction is not, it is true, strictly accurate. The expenses of the staff include also a part of the cost of construction of lines, &c. *Per contra*, we find amongst the working expenses the cost of instruments and other similar things, which are independent of the length of the lines. We may therefore admit, without much risk, that these inaccuracies mutually compensate one another.

Now, according to the general statistics for the year 1875, published by the *Bureau International* of Berne, the expenses of the ordinary budget in countries for which the above-mentioned distinction has been established amount on an average for the staff to 72·7 per cent., for *matériel* to 27·3 per cent.

Thus the average of the expenses dependent upon the distances between which the telegrams are transmitted is a little more than a quarter of the general expenses.

It follows that in the arrangement of tariffs the share allotted

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on an average to the element of distance ought to be reduced to a very small amount for telegrams exchanged at distances less than the average distance of transmission. It would, it is true, be more important for telegrams for a long distance; but, in order to keep an account of the distances in exact proportion to their value, it would be necessary to fix a tariff with minute details, and showing small progressive increases of charge, which would be entirely opposed to all modern progress.

CORRESPONDENCE.

ERRORS IN PRACTICAL TELEGRAPHY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The article of Sir James Anderson on Errors in Practical Telegraphy, of which the first part appeared in your first number, deserves certainly the attention of all persons interested in the welfare of telegraphy, particularly in the welfare of the more important, the international branch. It seems to me that the cause of mutilation of railway passengers presents some analogy with the cause of mutilation of our (telegraph) passengers, the telegrams, and that this analogy even goes so far as to include also the means to prevent these unfortunate accidents. In the researches on the Law of International Telegraphy (*vide* p. 53, &c.) I have treated the question of *accuracy* and *speed* very much from the same point of view as Sir James, and, as it may be interesting, should any of the possibly proposed remedies concur, I beg to offer my opinion without waiting for the continuation of the valuable article. In my mind the case may be shortly defined thus:—To increase the safety of railway passengers, employ proper intervals (block systems); to increase the accuracy of telegraph passengers, employ proper (regular) spacing (automatic instruments). This analogy does not, I think, require any further explanation. I only add, employ on important international telegraph lines, particularly on those where such strange passengers as Mr. "Alcidtug" are likely to be met with, the most experienced and thoughtful operators, and I am certain that in the long run we shall have a considerable saving of time and work now spent in tiresome repetitions. C. L. MADSEN.

Copenhagen, May 31st.

THE MUD BATTERY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your interesting description of Professor Hughes's Microphone you describe a simple form of battery, each element consisting of a tumbler with a plate of copper at the bottom upon which is placed some sulphate of copper. This is again covered with clay, in which the zinc is placed. It will probably be interesting to your readers to know that this battery was used largely by the late Electric and International Telegraph Company, and was called "the Mud battery." A full description of it will be found in the patent No. 2,555, of 1854, taken out by Mr. Cromwell Varley, chief electrician.

In the same patent will be found the sulphate of mercury battery which has recently been brought into notice by Mr. W. Warden as a standard of electric potential. T. S. MORISON.

IS THE BODY AN ELECTRICAL MACHINE?

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Allow me to inform "W. S. O. B." that though I have not observed *precisely* the phenomenon he describes, it is a very common occurrence when combing my hair to hear crackling sounds in dry weather, and in the dark the hair under these circumstances seems luminous at the instant, especially if the comb used be made of ebonite. This I have especially noticed in India. No doubt the friction of any two dissimilar bodies produces an electrification which, if circumstances are favourable, may be made visible, and this takes place in the human body as much as in any other substance. Those who were present at Prof. Tyndall's Juvenile Lectures on Electricity (1875) will not readily forget an experiment then tried. One person stood on an insulating stool and had his hair combed by an assistant, who drew the comb after each application through his hand so as to discharge it. By this means the person on the board was able by presenting his hand to a delicately-suspended board to make the board follow it. I would add that on a dry frosty night the electricities would not readily recombine owing to the insulation of the air, and that the haste with which the vest was pulled off and flung away more effectually prevented their recombination. I.

ERRATA.—In the abstract of Prof. Maxwell's paper, p. 21, line 23, col. 2, insert + before log.; line 32, col. 2, read 7·245 for 7 ·245: line 39, col. 2, read a for σ.

STUDENTS' COLUMN.

ANSWERS TO QUERIES.

1. The resistance of a wire is given by $R = \frac{k\,l}{a}$, where k is the specific resistance of the material, l the length, a the area of a cross section. If we have two wires whose specific resistances are k_1, k_2; their lengths l_1, l_2; and their diameters d_1, d_2, if the resistances are equal, we have from the above $\frac{k_1\, l_1}{d_1^2} = \frac{k_2\, l_2}{d_2^2}$, since area of cross section $= \frac{1}{4}\pi d^2$. Hence

$$\beta.\ \frac{x}{120} = \frac{d_1^2}{d_2^2} = \left(\frac{4·5}{1·5}\right)^2 = 9 \therefore x = 1{,}080 \text{ yards.}$$

$$\gamma.\ 138\, x^2 = 1000 \times \overline{2·5}^2 = 6250 \therefore x^2 = \frac{6250}{138} = \frac{3128}{69} = 45·2897.$$

$$\therefore x = 6·7 \text{ mm. diameter.}$$

I.

(I. also sent answers to questions 3 and 4.—ED. EL.)

QUERIES.

10. What is the principle of Wheatstone's Bridge? Describe the method of joining it up to determine.
    a. The resistance of a conductor.
    b. The internal resistance of a battery without using a second battery.
    g. The internal resistance of a galvanometer by means of its own deflexion.
11. How is the loop-test applied?
12. What is the use of the B. A. key in Wheatstone's Bridge?
13. How can I measure the E.M.F. of a galvanic element?—I.
14. *Aluminium*.—Is there any method known by which you may braize or solder this metal?
15. *Vulcanite*.—What means, if any, can be applied to highly-polished surfaces on vulcanite, so as to preserve it from decomposing whilst exposed to the action of light or sea air?
16. *Glass a Conductor*.—Is there a chemical test by which you may ascertain the presence of lead in glass without its being powdered? H. G. CHEESMAN.

(The remaining question from I. will be inserted next week. Time is required to engrave the diagram.—ED.)

THE PHYSICAL SOCIETY.

On Saturday last, the 25th inst., a general meeting of this society was held at the Science Schools, South Kensington—Professor W. G. Adams, the president, in the chair, when Sir William Thomson delivered a lecture on "a new method for discovering and measuring aeolotropy of electric resistance produced by aeolotropic stress in a solid." The distinguished lecturer, in the course of his remarks, pointed out that torsion of a metal tube within its limits of elasticity produces aeolotropic stress, of which the mutually perpendicular lines of maximum extension and maximum contraction are spirals, each very nearly at 45 deg. to the length of the tube. From the author's early experiments — described in his paper on the Electrodynamic Qualities of Metals, published in the "Transactions of the Royal Society for 1856"—showing a diminution of electric conductivity by pulling force in metallic wires, and Mr. Tomlinson's recent confirmations and extensions of those results, it is to be expected that the conductivity of the substance will be less in the direction of extension and greater in the direction of contraction in the stressed substance than the conductivity, equal in all directions, of the substance when free from stress. Hence, if an electric current be maintained along a tube, torsion would cause it to flow in spiral stream lines, with spirality of opposite name to that of the twist. The whole flow may be resolved into two components, one right along the tube, the other round it. The latter would—like the current through a galvanometer coil—deflect a needle hung in the interior of the tube, with its axis perpendicular to the tube when undisturbed; or it would magnetize a bar or wire of soft iron placed within the tube. The current itself would, except near the ends of the tube, produce no external effect directly, but either of those appliances may be used to give an external indication. Since the last meeting of the Physical Society, when the lecturer raised the question of the spiral electric stream lines in a twisted tube, experiments had been made for him by Mr. Macfarlane in the physical laboratory of the University of Glasgow on the last-mentioned plan, and on the former plan by Mr. J. T. Bottomley in the physical laboratory of King's College, London, by kind permission of Professor Adams, and with the valuable assistance of his staff. Mr. Macfarlane, using a small mirror magnetometer suspended externally in the neighbourhood of one end of an iron wire placed within a brass tube, found that when the spiral was right-handed the end of the wire next that end of the tube by which the current enters becomes a true north pole. Mr. Bottomley, with the cell and suspended mirror and needle of an ordinary dead beat mirror galvanometer supported by an independent support within a brass tube along which a current is maintained, found that the true north pole of the needle is moved towards the end of the tube by which the current enters. Thus, both Mr. Macfarlane's and Mr. Bottomley's observations confirm the anticipation that the

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electric conductivity is least in the direction of greatest extension, and greatest in the direction of greatest contraction of metal.

The apparatus by which Mr. Bottomley had made his experiments was exhibited to the meeting. It included a mode of balancing the effect on the internal needle by placing a circular portion of the main circuit at a proper distance from it, the centre and the plane of the circle being in and perpendicular to the axis of the tube. From a measurement of the distance from the centre of the circle to the needle, when the balance is obtained the ratio of the maximum to the minimum conductivity can be calculated.

At the close of the lecture the PRESIDENT expressed the thanks of the meeting to Sir William Thomson for carrying on the investigations he suggested at the last meeting, and they would be glad to hear the results of continued investigations at another meeting.

SOCIETY OF ENGINEERS.

At a meeting of the Society of Engineers held on Monday evening, May 6th, in the Society's Hall, Victoria-street, Westminster, Mr. R. P. Spice, president, in the chair, a Paper was read by Mr. St. George Lane Fox, on "The Lighting and Extinction of Gas by Means of Electricity." The author commenced by alluding to what had already been attempted in this direction, with special reference to the pneumatic system proposed some time ago, in which an extra pressure in the gas mains was made to act upon an apparatus provided for each lamp. He then explained the difficulties that presented themselves, and which led him to design the electric system, which he proceeded to explain. In this system the lamps to be operated upon are connected together by an insulated wire, so that electric impulses sent from one point or station will operate simultaneously on every lamp in the circuit, through the instrumentality of an apparatus with which every lamp is provided, so as to turn the gas on or off independently at any burner, and also to light it. The lamp apparatus consists chiefly of a small induction coil which produces the spark for lighting the gas at the burner, and the soft iron core of this coil supplies, in conjunction with a permanent magnet, the necessary force for opening and closing a valve of peculiar construction, which forms a special feature of the invention. The author having explained the construction of the apparatus by the aid of diagrams, and the general working of the system, proceeded to give an estimate of the cost of applying it, and of the saving that it was expected would result from its use. Taking a district of 3,000 lamps, placed forty-five yards apart, he estimated the first cost of the system with overhead wires at 4,886*l*. 15*s*., and that of the system with underground wires at 7,499*l*. 5*s*. The cost of working was placed at 4*s*. per lamp per annum, for cleaning, lighting, and extinguishing, equal to 600*l*. per annum. The cost of working on the ordinary system, as per estimates supplied by the gas companies, was stated to be 18*s*. per lamp per annum, or equal to 2,700*l*. The saving to be effected by the adoption of Mr. Fox's electric system, in working expenses, in gas saved morning and evening by simultaneous lighting and extinction, including interest at 2 per cent., was placed at 3,117*l*. 9*s*. 6*d*. Mr. Fox thus showed that by an outlay of 4,886*l*. 15*s*. by the overhead system, or about 7,499*l*. 5*s*. by the underground system, an annual saving of 3,117*l*. 9*s*. could be effected. By taking the interest upon the outlay at 7 per cent., a net annual saving of 2,775*l*. 7*s*. 6*d*. for the overhead system, or of 2,592*l*. 10*s*. for the underground system, would result.

REUTER'S TELEGRAM COMPANY (LIMITED).

The fourteenth ordinary general meeting of the shareholders of this company was held on Wednesday, the 29th of May, at the offices, 24, Old Jewry, under the presidency of Colonel Holland, the chairman of the board of directors.

Mr. F. J. GRIFFITHS (secretary), having read the notice convening the meeting, the report of the directors was taken as read. It stated *inter alia* that the net profits for the year ending the 31st of December last, after payment of current charges, and deducting rebate on unexpired subscriptions, amounted to 7,668*l*., including 122*l*. brought forward from the last account.

The CHAIRMAN, in moving the adoption of the report, said last year he appeared before the shareholders not with unmixed satisfaction; but he then stated that the causes which had produced that unsatisfactory state of things were entirely exceptional, and he believed were not likely to occur again. He hoped the shareholders would be of opinion, after perusing the report and the accompanying balance-sheet, that his prognostications were correct. The business of the company during the past year, although not extremely flourishing, had been such as to enable them to declare a 7½ per cent. dividend for the year and recoup to the reserve a large portion of the amount which last year they were compelled to take from it for the purpose of declaring a moderate dividend. Referring to the figures in the balance-sheet, he pointed out that sundry debits and credits stood very much about the same. They were "floating" figures, and they were given as they stood at the end of the year; but almost every portion of the two sums had been paid off since. They had looked carefully over the list of debtors, and they believed every portion to be thoroughly good. They would be interested to know that the lease of their house, which stood last year at 1,990*l*., was now 1,490*l*. They took out of the profits 500*l*. a year to reduce this amount, so that when the lease expired there might be nothing left to pay; and in the course of three or four years the whole amount would be paid off. With regard to current expenses, owing to the political state of Europe they had been very heavy, but by economy they had kept them below the expenses of last year. Again, the amount for telegrams and agencies, which last year stood at 47,900*l*., was now 48,900*l*., or 1000*l*. more, but they could easily understand that when they had more business they must pay more for transacting it. On the other hand, subscriptions and commissions, which last year were 67,400*l*., now amounted to 71,900*l*., so that, although they had paid rather more, they had gained a great deal more. They must all feel, as the Board did, regret that their able managing director, Baron de Reuter, in consequence of failing health, had been compelled to resign the office which he had held so long and ably, and so much to the advantage of the shareholders and the general public. During the past two or three years he had been compelled to make long absences, and last year he was away several months. During that time his son, Mr. Herbert de Reuter, officiated as managing director, and carried on the entire duties of the office. The secretary was also absent for many months on an important mission to Australia and India; so Mr. de Reuter had the whole business of the office on his shoulders, and admirably had he come through the trial [cheers]. They had therefore had no doubt whatever in their mind that, in having appointed Mr. de Reuter managing director of this company, they had appointed the fittest man for the place. They found that a revision of the tariff and an inspection of their establishments were all very necessary to their continued prosperity. Mr. Griffiths had visited all their principal establishments in Australia and India, had had interviews with the various governors and the leading men at those places, and had entered into and concluded business arrangements which would be very beneficial to them. He then moved the resolution for the adoption of the report.

Mr. STOPFORD formally seconded the motion, which was put to the meeting, and carried unanimously.

The CHAIRMAN then said that at the earnest solicitation of the directors Baron de Reuter had consented to remain on the board provided the shareholders elected him a director, which he had no doubt they would unanimously do. He moved "That Baron de Reuter be elected a director of the company."

Mr. STOPFORD seconded the motion, expressing his pleasure at doing so.

The motion was carried unanimously, and in reply,

Baron de REUTER thanked the meeting for the confidence thus shown in him.

The CHAIRMAN then moved the re-election as a director of Admiral the Right Hon. Sir John C. D. Hay, Bart., M.P.

Baron de REUTER seconded the motion, which was carried unanimously.

On the motion of Mr. REW, seconded by Mr. LOVEDAY, the retiring auditors, Messrs. Quilter, Ball, and Co., were re-elected.

Mr. REW then moved a vote of thanks to the chairman, the directors, and the secretary.

Mr. ELLISON seconded the motion, which was carried unanimously.

The CHAIRMAN, in reply, said he was thankful to say that for the last fourteen years he had had to return thanks to the shareholders for their kind appreciation of the labours of the Board. Thanks to the sound position of the company, their duty had been all along a most satisfactory and gratifying one; and, with such able colleagues as he had had, it was no wonder that the company had prospered.

The proceedings then terminated.

LITERATURE.

ELECTRIC TELEGRAPH CABLES.

Laying and Repairing of Electric Telegraph Cables. By Capt. Hoskier. Spon and Co.

Under the above title Captain V. Hoskier, of the Royal Danish Engineers, has written a very useful little volume, which we have no hesitation in saying should be read by every one who wishes to know something of telegraph engineering as applied to cable work.

The experienced engineer will find nothing in this book with which he ought not to be already acquainted. We regret to say that the subject is too briefly dealt with to give the electrical tyro much assistance. However, we do not think that any one outside the profession who wishes to be acquainted with the general run of applied science will omit to find room in his library for a copy of this book—the very first of its kind which has appeared.

It is evidently, as Captain Hoskier himself points out in his preface, a compilation of notes and jottings on the laying and repairing of the Great Northern Telegraph Company's cables, and as such may be of some use in guiding other companies to the development of organisation among their staff of electricians and operators.

In selecting the route, &c., for a cable it is not at all so easy to select your own depth or bottom, and this being the case, the cables themselves must have some special design according to the depth and nature of the bottom. Wherever cables have to be laid it is of the first importance that such places should be selected which will be accessible for repairs, if possible, at any time of the year.

It is not easy to understand why the Admiralty Charts do not show the position of submarine cables so as to give mariners a chance of keeping clear of them, at least when submerged in such places as may be used for anchorage. A captain, for instance, drops his anchor, and in hauling it up again he finds it has fouled something; a submarine cable is not very likely to enter his mind as the obstruction; so, unless the cable gives way, he loses his anchor and chain. The cable being broken involves loss of traffic and the expense of repairing. If the cable is raised to the surface and the anchor cleared all may be well when the cable regains the bottom.

If a captain accidentally fouls a cable, the fault, as the matter now stands, is not his; but, if a regulation could be made subject to international legislation, that any one fouling a cable should report the same with whatever nautical observations and bearings are possible at the time, we should probably hear less of cables being broken, and even if broken, the spot for repairing would be readily indicated. A penalty should be inflicted when damage resulted if the fouling was not reported.

The discussion of the subject is one worthy of the Telegraph Congress, and we hope some steps will be taken to bring this matter forward. The nautical portion of the subject is almost entirely left out, and we hope in a future edition to see a chapter devoted to the methods of taking observations, temperatures, &c. The author says that in stowing a cable into a ship it is important to keep the vessel on "an even keel," by so arranging the weights of cable, coal, &c. Now, this is simple enough; but in stowing a cable on board, the engineer has not only to keep this in view, but he has to provide, as near as circumstances will permit, that in paying the cable out he maintains the same condition. The consumption of coal is an important matter for the engineer to keep before him, and the position of the coal bunkers with reference to the cable tanks. If the vessel is fitted with tanks for water-ballast, this will enable the ship to be kept more nearly on an even keel. We cannot see that a consort ship is necessary for cable expeditions. Their employment must necessitate a heavy drag on the expenses; still, when working in uncertain depths or bottoms, or not easily navigable channels, it is economy to have some kind of pilot, but for this a steam launch or boat may be in most cases sufficient.

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The different descriptions of grapnels in use, and the treatment of cables in deep water, are far too scantily treated; but this, no doubt, is due to the fact that the author's experience is confined to cables not in great depths.

With respect to the cores in tanks, if the advantage of having them open is simply for cutting cables in the eye, to avoid turning over in case of faults, we consider the recommendation not likely to be approved by any engineer who knows what carrying a faulty cable to sea means. A piece of golden advice is, never have a faulty cable on board, and, if a fault crops up, be satisfied with nothing short of its absolute removal, unless the cable so cut off is not likely to be required, and will not entail splicing at sea with risk.

The author has treated so fully of the coiling into the ship's tanks, that the only omission we have to note is the protection of the lay-out. This is done by placing on each side of the length of cable, from the core to the side of the tank, a piece of feathered boarding, which prevents the superincumbent weight of cable resting on it. The lay-out being made in different parts of the tank for the different flakes coiled in, keeps the surface even.

In paying out, the trough, in addition to keeping the cable straight, prevents it fouling with anything on deck, as portions of the machinery itself, ventilators, &c. Several turns are taken round the brake-wheel, with a view to obtain a certain grip, and underneath is a knife arrangement, which keeps the running turn clear; without this there would be a risk of over-riding and serious mishap. The brake-wheel revolves in a tank of water, which keeps the wheel itself cool, and prevents the heating of the cable from the friction which is possible from slipping, or the rubbing of two of the turns against each other. The indicator has usually a strong bell, which strikes with each revolution, so that it is not necessary to keep one's eye on the measuring arrangement to know that all is going on well.

In the treatment of the formula for the strain indicated by the dynamometer, it would have been useful for the general reader if the author had given the trigonometrical functions as well as the algebraic. There is evidently a difference of opinion on the regulation of the strain on a cable during paying out, and, in spite of the statement that this formula is utilised, an idea exists that there is a great deal of the rule of thumb imported into the mechanical treatment of slack, &c. Allowing that the dynamometer indicates absolutely the strain put on, when the machinery is stationary on shore, can we assume, with the ship tossing about, or rolling, that strains of from 5 to 150 cwts. are more than approximately indicated? In grappling for a cable, when the grapnel is going over uneven and rocky ground, the strain is not even and uniform, but the dynamometer is affected by sharp and sudden jerks.

The convenience of paying out cables from the bows of a ship is principally in clearing the propeller and facilitating repairs, or handling of the cable in the event of accident.

In buoying cables, the author says that in deep water the buoy is usually made fast to the cable itself. It is well to point out that this cannot be done without risk, more especially on hard or rocky bottoms, and certainly not in a rough sea. We should like to have seen a description of buoy ropes and grapnel ropes, and the mooring of mark buoys. The idea which the author would leave on the mind of anyone, who has not seen repairing at sea, is that the operation is one of extreme simplicity. To give an illustration, we suppose the electrician, by his tests, reports a fault, say 250 miles from a station; this distance is first measured off on the "line of cable" laid down on the chart. The latitude and longitude of this point is obtained, and references to the paying out logs are made to see whether anything special occurred on board when paying out at this spot. We will suppose that, a little distance from this locality, a sounding is recorded, and good description as to the nature of the bottom. Whilst running to this spot a buoy is got ready for mooring, and the necessary rope, chain, and anchor are all attached. The captain has made sure of his position by the necessary observations, and a sounding is then taken. All the circumstances being confirmed, the mark buoy is let go. This acts as the working point for the ship. On the other hand, the weather may be overcast, the noon observation may make the ship's position anywhere as to that of the cable, the bottom may be gravel instead of mud, the depth of water may be 200 or 300 fathoms less or greater than shown on the line of cable near the required spot. Nothing can be done until all this is cleared up; and, if bad weather has set in, it may be weeks before anything can be done. In sight of land observations are soon taken, and a cable can be found sometimes in a few hours, but in mid-ocean it is a very different thing. From this it is obvious that buoys must not only be selected with reference to the load they will carry, but should be so large as to be conspicuous at some distance in hazy weather. On a mud bottom a cable may sink so far into it that a heavy grapnel should be used to make sure of its sinking into it. On rocky or rough bottoms it is a common thing to find the grapnel when picked up minus a prong or two. When working on such bottoms a heavy chain is attached as a tail to the grapnel to prevent jumping. A grapnel so broken is useless. Short prongs, in so far as the leverage for obstacles is reduced, are better for such bottoms. When a ship has to work in such a depth that she cannot drop her anchor it is usual to put a light on the mark-buoy at night, so that the ship may not drift from her position. In a strong current the ship will frequently require steaming up to the buoy. A few words might have been added with reference to repairing cables in a tide-way. The undermining of cables is certainly not to be recommended unless we know that a short distance only will be required to be so treated; if a tension is put on the cable when this is being done, the cable so treated is of little value when picked up, and we presume no company would allow this handling of their cables, which has certainly no advantage in its favour.

TELEGRAPH SHARE LIST.

Amount of Issue.	Amount of Share.	Paid on Share.	Company.	Reserve as per last Report.	Dividends calculated at rate per cent. per annum. 1875. %	1875. %	1876. %	1876. %	1877. %	1877. %	When Payable.	Prices. 1875. Highest.	1875. Lowest.	1876. Highest.	1876. Lowest.	1877. Highest.	1877. Lowest.
£3,254,580	Stock	100	Anglo-American	Deferred receiving no dividend until 6 per cent. has been paid to Preferred.	5	year.	5	4†	3	5	† Div. 5 % per ann. for quarter ending Dec. 31, 1876, 2% for quarter ending Mar. 31, 4 % for quarters ending June 30 and Sept. 30, 6 % for quarter ending Dec. 31, 1877, and 4 % for quarter ending March 31, 1878.	51½	75½	53	68½	52	62¼
1,872,710	Stock	100	Do. Preferred B		—	—	10	2	6	6		Crtd	1876.	75	93	79	88½
1,872,710	Stock	100	Do. Deferred A		—	—	Nil.	6	Nil.	4		Crtd	1876.	29	44	25½	38
90,000	10	All	Brazilian Submarine	120,000	5	5	5	5	5	5	Quarterly.	6	7¾	5¾	7¾	5⅞	6¾
—	10	All	Cuba (Limited)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	10	All	Do. 10 per cent. Preference	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	10	9	Direct Spanish (1)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	10	All	Do. 10 per cent. Preference	—	—	—	—	—	—	—	—	—	—	—	—	—	—
65,000	20	All	Direct United States	Nil.	—	Nil.	Nil.	Nil.	Nil.	5	Quarterly.	7	13	6¼	11½	9½	13¾
359,700	10	All	Eastern (Limited)	110,000	5	year.	5	5	5		aJany., April, July, Oct.	6⅜	8	5	7⅛	6⅝	8¼
199,750	10	All	Eastn. Exten. Australasia & China	125,404	5½	year.	5	year.	5	year.	aJany., April, July, Oct.	7	8¼	5⅛	7½	6⅞	8
—	100	All	Eastern 6 per cent. Debentures	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	100	All	Do. 5 per cent. Debentures	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	10	All	Do. 6 per cent. Preference	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	100	All	Eastn. Exten. 6 p.c. Deben. (1875)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	10	All	German Un. Tl. and Tst.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,500,000	10	All	Globe Telegraph and Trust	Nil.	5	7 4-5	4½	7 5-6	3⅜	7 6-7	bJany., April, July, Oct.	5⅛	6¾	4¼	5⅞	4¼	5¼
1,500,000	10	All	Do. 6 per cent. Preference		6	6	6	6	6	6	Jany., April, July, Oct.	9¾	10½	9¼	10⅛	9¼	10½
150,000	10	All	Great Northern. Shares to Bearer, or can be Regstrd.	85,543	5⅝	year.	6⅜	year.	6⅜	year.	5 % intrm. Jan. 1, July 1. Final Dividend April.	7½	11½	7	9¾	7	8
—	25	All	Indo-European	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	10	All	Mediterranean Extension (1)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	10	All	Do. 8 per cent. Preference	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	18	All	Reuter's (Limited)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
65,000	10	All	West India and Panama	16,000	Nil.	Nil.	Nil.	Nil.	1	1	‡ Converted from a 10 %	1⅜	4¾	⅝	2½	1⅝	3⅝
34,563	10	All	Do. 6 per cent. Preference		7/6ac	year.	10/ac	year.	6‡	6	into a 6 % 1st Preference.	9	12	7	11	7½	11
67,500	20	All	Western and Brazilian	7,793	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Half-yearly.	9½	18¼	4¼	10⅜	4½	5¾
$1,500,000	$1000	All	Western Union Telegraph 7 per cent. First Mortgage Bonds	—	7	7	7	7	7	7	May, November.	102½	108	105	109¼	106	113
£1,030,000	200	All	Do. 6 per cent. Sterling Bonds	Redeeemable by annual drawings at par.	6	6	6	6	6	6	March 1, September 1.	86	93	89	98	94	101

a Year ends March 31st. Interim Dividend of 5 per cent. Final dividend in July. *b* Year ends July 18th. Final dividend in July.

Shrs.	Pd.	Companies.	May. Th., 30.	F., 31.	S., 1.	M., 3.	June. Tu., 4.	W. 5.
Stk.	100	Ang-American (1)	—	60½, 61¼	61¼	—	61¾	62⅜
Stk.	100	Do. Preferred	88½, 89	89½	89½, 9½	91½	91, 90¾	91½, 92½
Stk.	100	Do. Deferred (a)	—	33⅜, 34½	—	34⅜, 35	35½	35¼, ½
10	All	Brzn-Submarine	—	6¾	—	6¾	6¾	—
10	All	Cuba (Limited)	—	9 9-16, 7-16	—	9½	—	—
10	All	Dct. U.S. Cable (1)	13½, ⅝	13½, ½	—	13½, ¾	—	—
10	All	Eastern (Lmtd.)	—	7⅝	—	7 9-16, ⅝	7 11-16	7⅝
10	All	Do. 6 p. c. Pref.	—	—	—	—	11½	11¾
10	All	Estrn. Ex., Aus., and China	7¾, 13-16, ⅞	7¾, 13-16	7¾, ⅞	7 13-16, ¾	7 13-16, ¾	7¾, ⅞
10	All	Globe Tl. & Tst. (1)	5¼, ⅛	5 3-16	5¼	5¼	5¼, 5-16	5¼
10	All	Do. 6. p. c. Pref.	10⅜	—	—	—	10⅜, ½	10⅜
10	All	Great Northern	8⅜	8⅜, 5-16	8 5-16	8 7-16, ⅜	8 9-16	—
10	All	Mediter. Ex. (1)	—	—	—	2 13-16	—	—
10	All	W. India & Pan. (1)	—	2¼, 3-16	2 3-16	2¼, 3-16	2¼	2 5-16, ¼
10	All	Do. 6 p. c. 1st Pref.	8¾	—	—	—	8 15-16	—
10	All	Do. 2nd Pref.	—	—	—	—	8½	—
20	All	*West. & Braz. (1)	4⅝, ½	4⅝	—	—	4½	5⅜, ½

(a) Deferred receiving no div., until 6 p. c. has been paid Preferred.

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NOTES.

A Good Example.—A firm of cab proprietors at Halifax have established a telephone between their offices and the Railway Station, and also with their stables in another part of the town.

Queensland.—In Queensland, telegraph extension is in progress between Dalrymple and Junction Creek, 170 miles; Gympie and Kilkivan, 50 miles; and Burdekin and Cape Bowling Green, 50 miles; making an addition of 270 miles to the existing telegraph system.

Great Northern Telegraph.—It is announced that the Hong Kong Amoy cable has been provisionally restored. The further repairs required have been postponed until the Singapore route has been re-established. Messages are received for all China and Japan stations.

The Telegraphic System of America comprises about 300,000 miles of wire, of which the Western Union Company has about 195,000, the Atlantic and Pacific Company (now consolidated with the former), 36,000, the Montreal Company 20,000, the Dominion Company 7,000, and smaller companies and railroads 40,000.

Electric Light at Paris.—Electric lighting will be well illustrated in Paris this year; the other day the regular lighting of the Avenue de l'Opéra—the new street which has the Opera house at one end, and the Théatre Français at the other—was lighted for the first time by the contractors who are working the Jablochkoff patents, and although ordinary street lamps were used the effect was deemed satisfactory. The Arc-de-Triomphe was also similarly lighted on the same evening. The Place de l'Opéra is brilliantly lighted every evening that the house is open. The Madeleine and the Corps Législatif are also to be lighted in the same manner.

Properties of Electrolytically-deposited Metals.—In copper deposited by voltaic action M. Schutzenberger recognised properties different from ordinary copper, and he has now found that other metals behave in the same way. Lead especially yields very well-marked phenomena. Electrolytic copper always gives, though in a feeble manner, the reactions of acetic acid. As a conscientious analyst, M. Schutzenberger remarks that the deposited metals were not free from the presence of foreign substances, in too small quantities, indeed, to cause the peculiarities which he has noticed, yet so that he cannot declare the metals experimented upon perfectly pure. M. Henri Sainte-Claire Deville agrees with him in pronouncing that these foreign substances cannot play any sensible part, and that we have here examples of actual allotropic modifications.

Thermo-Electric Properties of Liquids.—By using an improved apparatus, which he described at a recent meeting of the Royal Society, Mr. G. Gore, F.R.S., has discovered several exceptions to the effect he formerly obtained, viz., that acid liquids are thermo-electro-positive, and alkaline ones thermo-electro-negative; and, reasoning upon the results obtained in his most recent experiments, concludes:—

(*i.*) That the electric currents are not produced by chemical action. (*ii.*) Nor by a temporary disassociation of the constituents of the liquid. (*iii.*) Nor by the action of gases occluded in the metals. (*iv.*) But that they are produced purely and solely by the heat, and that heat disappears in producing them. (*v.*) That they are immediate or direct effects of the heat, and that aqueous conducting liquids, therefore, possess true thermo-electric properties. (*vi.*) That the current is a result of a difference of thermic action at the surfaces of the two pieces of metal. (*vii.*) That it is a product of a suitable molecular structure of the liquid, a change of such structure resulting from alteration of temperature, and a direct conversion of heat into electricity; and (*viii.*) That the circumstance which is most influential in enabling heat to produce the currents, and most determines their direction and amount, is a suitable molecular structure of the *liquid*.

Irregular molecular changes in several liquids examined have been discovered, and it is suggested that the method should be further used to prosecute researches in this direction. In the case of platinum, when immersed in some saline, alkaline or acid liquids, a slight rise of temperature takes place, and a similar rise in temperature probably takes place when other metals are immersed. The results obtained support the contact theory of voltaic electricity.

Specific Inductive Capacities of Certain Dielectrics.—It is important that authoritative determinations of specific inductive capacity should be made. Professors Ayrton and Perry, in a paper sent from Tokei, Japan, show that certain modifications must be introduced in the fundamental notions of the mathematical theory of electricity because Faraday's conclusion as to the specific inductive capacity of all gases being the same as that of air is incorrect. Mr. J. E. H. Gordon has carried out some experiments in this direction by a new method, the essential features of which are that it is (*i.*) a zero method, (*ii.*) the electrified metal plates never touch the dielectrics, (*iii.*) no permanent strain is produced or charge communicated, as the electrification is reversed some 12,000 times a second. The following are the results obtained with solid dielectrics in plates 7 inches square and from ¼ inch to 1 inch thick:—

Dielectric.	Specific Inductive Capacity.		
Ebonite, four slabs, ¾, ½, ½, ¼ in. thick	(1) 1·5593 (2) 1·5553 (3) 1·5671 (4) 1·5669	mean	1·56215
Best quality gutta percha			1·5939
Chatterton's compound			1·6080
Indiarubber (black)			1·5502
Ditto (vulcanised)			1·5988
Sulphur			1·6127
Shellac			1·6362
Solid paraffin S.G. ·9109 at 11° C. ... Melting point 68° C. ... Six slabs, each about ¾ in. thick ...	(1) 1·4986 (2) 1·4943 (3) 1·4920 (4) 1·5033 (5) 1·4936 (6) 1·5034	mean	1·49753
Bisulphide of carbon (probable)			1·4474
Chance's optical glass slabs nearly 1 in. thick: Double extra dense flint			1·6840
Extra dense flint			1·6727
Light flint			1·6677
Hard crown			1·6872
Common plate glass, two slabs each, about 1in. thick	(1) 1·6933 (2) 1·6903	mean	1·6918

It will be seen that these figures differ considerably from those previously obtained, and we might suggest that other experimenters should spend a little time in confirming or in showing the incorrectness of these results.

Fire Alarm Telegraphy at New York.—The watchword of the world is progress. The son refuses to walk in the footsteps of his father, and turns into paths and fields altogether new. Old methods are cast aside as antiquated, and the discoveries of science utilised. America is going ahead, determined to outstrip the old world in the race of progress. Among other things, she has perfected fire alarms in her larger cities, whilst we are still satisfied to follow the old fashion. Science and experience have aided Messrs. Emrick and Smith to design, and Messrs. Pierce and Jones to construct a system of electrical machinery which enables a fire to be located at once, and hence the necessary action for putting it out to be taken without loss of time. This system comprises sixty circuits of 120 wires. There are 550 street

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boxes and 85 points, to which alarms are transmitted from head-quarters, including engine and truck houses, the quarters of the chief engineer, police head-quarters, the fire-boat Havemeyer, &c. The great bunches of wires are carried into the loft of Firemen's Hall from two enormous poles in front. In the loft are situated the "lightning arresters." On each circuit is a galvanometer, which indicates at all times the condition of the circuit and strength of the battery. Should an outside disturbance occur on any wire it is immediately shown by the little needle of this galvanometer. The existence of the disturbance ascertained, the wire is at once switched to an electric measuring instrument, where, by means of a rheostat, the location of the alarm is accurately determined. A recording instrument, with recording pens, prints a signal in ink on paper. By a single movement of any of these levers, a fire signal may be sent from a street box direct, and sounded upon a small instrument in each company quarters. The transmitters, which are used for the purpose of sending alarms and striking them upon large gongs in firemen's quarters, are three in number, and are placed upon pedestals in the centre of the platform. Two of these have been for some years in use. They performed their work well, but another and a larger machine was added to meet the requirements of the service. An alarm is received and sent out in the following manner. When a street box is pulled for a fire the circuit on which it is situated is at once indicated and the signal number sounded on a bell and recorded by the register, which is started in motion by the action of the street box itself. The operator immediately pulls down the lever of the circuit which is working, and this movement taps the signal on all the small instruments of the engine and truck houses without the loss of an instant of time. In the meantime the assistant operator has prepared the transmitter, and the operator at once starts it. This rings all the big gongs, which, on account of their size, necessarily ring somewhat slower than the small ones. There is an extensive system of machinery for testing the wires, batteries, &c. Each one of the articles of machinery is duplicated; so that, in case of failure from any cause, by a single movement of a switch the injured one is thrown out and the duplicate instantly put in its place. Delay is thus rendered impossible. The battery room on the ground floor is connected by 200 wires to the switch board of the operating room, and employs 1,250 battery cells. It is thought that these improvements have brought the fire telegraphic system of this city as near perfection as possible.

On the Spectra of Metalloids.—Dr. A. Schuster presented a paper on this subject to the Royal Society on April 25, which seems to be the first of a series. He gives details of certain experiments on oxygen performed at the Cavendish Laboratory, Cambridge. He says:—"The chief difficulty in the way of a complete investigation of the spectrum of oxygen consists in the great disturbing influence of the presence of even a small quantity of any carbon compound. Amongst a great many oxygen tubes which were filled by various makers I only found one which showed the spectrum of pure oxygen; all the others gave a spectrum of carbonic oxide. It is therefore necessary in filling oxygen tubes to avoid all greased joints and all india-rubber tubings. Great care was taken to have the tubes filled with pure oxygen, and the effect of the electrodes was eliminated by varying the metals. Aluminium, platinum, silver, brass, and iridium were used as electrodes. Any possible effect of the glass was eliminated by finally repeating all experiments in a glass receiver six inches in diameter, so that no part of the spark came nearer than two-and-a-half inches to the glass. In this way it is believed all possibility of error due to the presence of any possible impurities was avoided. Four different spectra of oxygen must be distinguished. At the lowest temperature at which oxygen becomes luminous it gives a continuous spectrum. As the temperature is gradually raised the continuous spectrum is successively transformed into two distinct line spectra, which I call respectively the compound line spectrum and the elementary line spectrum. The generation of one always involves the destruction of the other. The fourth spectrum is that which is always seen in vacuum tubes at the negative pole. *The continuous spectrum* is obtained when the break contact of an ordinary Rhumkorff coil is put out of adjustment so as to weaken the spark. Under ordinary circumstances the spark gives the *elementary line* spectrum. Plücker from his first experiments saw the *compound* line spectrum consisted of four lines, one in the red, two in the green, and one in the blue. Afterwards, however, he increased the number of lines. Dr. Schuster says of these lines "they come out equally well whatever way the oxygen is prepared, whatever the nature of the electrode, and I have seen them under the large glass receiver already mentioned. The following is the appearance of an oxygen as it undergoes gradual exhaustion. When the pressure is sufficiently diminished to allow the spark to pass it shows a yellow colour, and the spectrum is perfectly continuous. Almost immediately, however, the four lines are seen in the capillary part of the tube above the continuous spectrum. The continuous spectrum in the wide part is then stronger than in the narrow part. The four lines seem to have taken away part of the energy of the continuous spectrum. As the exhaustion proceeds the spark spreads out in the wide part, and the continuous spectrum is therefore diminished and becomes less intense than in the capillary part; but it gradually loses in intensity also in the narrow part, until the four lines stand out on a perfectly black background. *The Spectrum of the Negative Pole* consists of five bands, one of which is too weak to be measured. Careful measurements of the others have been taken. With regard to the explanation of the separate spectra found at the negative pole in nearly all gases, I incline to the view that they are due to separate molecular compounds which are formed at the pole; for, when the pressure is very small, the spectrum of the negative pole extends throughout that half of the tube which encloses the negative pole; and, if the current be suddenly reversed, the spectrum of the negative pole will still be seen at first in that part which was the negative half and now is the positive half of the tube; but it will gradually disappear and a permanent state will be established, in which the spectrum of the negative pole is, as before, only seen in the negative half. That it is the reversal and not the interruption of the current which produces the result is easily proved by interrupting the current and at once closing it again the same way, when no difference will be seen. If, however, the current be left interrupted for some time, say one minute, so that any compounds which may have been formed in the negative half may diffuse into the other half, and if then the current is closed, either the same or the opposite way, the negative spectrum will be seen at first throughout the tube, but gradually disappear in the positive half. If the current be rapidly reversed in succession, after a little while, when the effect of the first reversal has disappeared, the permanent state will always be established at once, and the spectrum of the negative pole will appear only in the negative half. If after the last experiment the current be interrupted for some time and then closed, the spectrum of the negative pole will at first be seen throughout the tube, and gradually disappear in the positive half."

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DYNAMO-ELECTRIC MACHINES.

[CONTINUED.]

Experiments were also made to determine what effect on the amount of light was produced by so adjusting the carbons that the front edge of the upper one was in line with the centre of the lower one. Fig. 21 shows such an adjustment, and is from a figure photograph taken while measuring the light produced from the small Brush machine, running at 1,250 revolutions per minute, and resulting as follows :—

Front	2,218 candles.
Side	578 „
„	578 „
Back	111 „
	3,485 ÷ 4 = 871.

The light produced by the same machine, under the same conditions, except the carbons being adjusted in one vertical line, was 525 candles. This would seem to indicate that nearly 66 per cent. more light was produced by this adjustment of the carbons; but a close study of the conditions satisfies us that such is not the case, and that there is no advantge to be derived from such adjustment, except when the light is intended to be used in one direction only.

TABLE I.

SHOWING WEIGHT, POWER ABSORBED, LIGHT PRODUCED, ETC., BY DYNAMO-ELECTRIC MACHINES TESTED BY A COMMITTEE OF THE FRANKLIN INSTITUTE, 1877-8.

Name of Machine.	Weight in pounds.	Copper Wire in Armature. Size.	Copper Wire in Armature. Weight.	Copper Wire in Field Magnets. Size.	Copper Wire in Field Magnets. Weight.	Revolutions of Armature per minute.	Foot-pounds of Power consumed.	Horse-power.	Light produced in Standard Candles. Total.	Light produced in Standard Candles. Per h.p.	Foot-pounds of power con-sumed per candle light.	Size of carbons.	Length of Carbon consumed per hour. +	Length of Carbon consumed per hour. −
Large Brush	475	·081 in.	32 lbs.	·134 in.	100 lbs.	1,340	107·606	3·26	1,230	377	87·4	½ × ½	1·78	·34
Small Brush	390	·063 in.	24 lbs.	·096 in.	80 lbs.	1,400	124·248	3·76	900	239	137·	½ × ½	1·91	·58
Large Wallace ...	600	·042 in.	50 lbs.	·114 in.	125 lbs.	800			823					
Small Wallace ...	350	·043 in.	18½ lbs.	·088 in.	41 lbs.	1,000	128·544	3·89	440	113	292·	¼ × ¼	2·45	·073
Gramme	366	·059 in.	104 lbs.	·108 in.	104 lbs.	800	60·992	1·84	705	383	85·	¼ × ¼	3·15	·55

We would here call the attention of those who may compare our results with those obtained at the recent experiments at South Foreland, England, to the following statement upon this point in the report of Mr. Jas. N. Douglas, engineer to the Trinity House, page 16 of the official report :—

I have found this arrangement of the carbons (the axis of the bottom carbon nearly in the same vertical plane as the front of the top carbon), and assuming the intensity of the light with the carbons having their axis in the same vertical line to be represented by 100, the intensity of the light in four directions in azimuth, say E., W., N., and S., will be nearly as follows :—

East or front intensity	287 to 100
North or side „	116 to 100
South or „ „	116 to 100
West or back „	38 to 100
	557 ÷ 4 = 139 to 100.

In measuring the candle-power of the light produced by each machine I have given the mean intensity obtained in the direction of the photometer, the carbons in lamp working with the Holmes and Alliance machines being always arranged with the axes in the same vertical line, and the carbons in the lamp working the Gramme and Siemens machine being always arranged with the front edge of the top carbon nearly on the centre of the bottom carbon.

It is, therefore, evident that the results given by Mr. Douglas must be divided by 2·87 in making a comparison with those obtained by us.

Thus, in the table on page 31, official report, in the column headed Light produced by H. P. in standard candles, he gives for the Gramme machine condensed beam 1,257; but if this be divided by 2·87 we have 438 candles, which is, no doubt, still too high, our result of 383 candles per H.P. for the Gramme being obtained under the careful and rigid conditions before named.

Now that the conversion of motive power into electricity, and the use of the latter for lighting, the deposition of metals, etc., are rapidly gaining in importance, it has become desirable that reliable data be obtained as to the efficiency of the various types of machines designed for producing electrical current from motive power. In entering this comparatively new field of research we have been met by peculiar difficulties, owing to conditions that do not exist in the various forms of batteries used as sources of electrical power. In many battery circuits a high external resistance may be employed, and the electromotive force remain comparatively constant, while in dynamo-electric machines, in which the reaction principle is employed, the introduction of a very high external resistance into the circuit must be necessarily attended by decided variations in the electromotive force, due to changes in the intensity of the magnetic field in which the currents have their origin. Moreover, a considerable difficulty is experienced in the great variations in the behaviour of these machines when the resistance of the arc, or that of the external work, is changed. Changes, due to loss of conductivity by heating, also take place in the machine itself. The variations above mentioned are also attended by changes in the power required to drive the machine, and in the speed of running, which again react on the current generated. There are certain conditions in the running of dynamo-electric machines designed for light, under which measurements must be made, viz. :—

1. The circuit must be closed, since, on opening, all electrical manifestations cease. 2. The circuit must be closed through an external resistance equal to that of the arc of the machine. 3. The arc taken as the standard must be the normal arc of the machine. This condition can only be fulfilled by noticing the behaviour of the machine while running, as to the absence of sparks at the commutator, the heating of the machine, the regularity of action in the consumption of carbons in the lamp, &c. 4. The speed of the machine must be, as nearly as possible, constant. 5. The power required to maintain a given rate of speed must be, as nearly as possible, constant.

The machines submitted to us for determinations were as follows, viz. :—

1. Two machines, of different size and of somewhat different detailed construction, built according to the invention of Mr. C. F. Brush, and styled respectively in our report as A^1, the larger of the two machines, and A^2, the smaller.

2. Two machines, known as the Wallace-Farmer machines, differing in size and in minor details of construction, and designated respectively as B^1, the larger of the two, and B^2, the smaller. In the case of the machine, B^1, the experiments were discontinued after the measurement of the resistances was made, insufficient power being at our disposal to maintain the machine at its proper rate of speed.

3. A Gramme machine of the ordinary construction.

All the above machines are constructed so that the whole current traverses the coils of the field magnets, being single current machines, in which the reaction principle is employed. In the case of the machine designated A^2, the commutators are so arranged as to permit the use of two separate circuits when desired. For the purpose of preserving a ready measure of the current produced by each machine, under normal conditions, a shunt was constructed by which an inconsiderable but definite proportion of the current was caused to traverse the coils of a galvanometer, thus giving with each machine a convenient deflection which could at any time be reproduced. As the interposition of this shunt in the circuit did not appreciably increase its resistance, the normal conditions of running were preserved. As indicating the preservation of normal conditions in any case, the speed of running and the resistances being the same as in any previous run, it was found that when there was an equal expenditure of power, as indicated by the dynamometer, the current produced, as indicated by the galvanometer, was in each case the same.

[TO BE CONTINUED.]

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S.S. SHERARD-OSBORN AND CABLE LAYING.

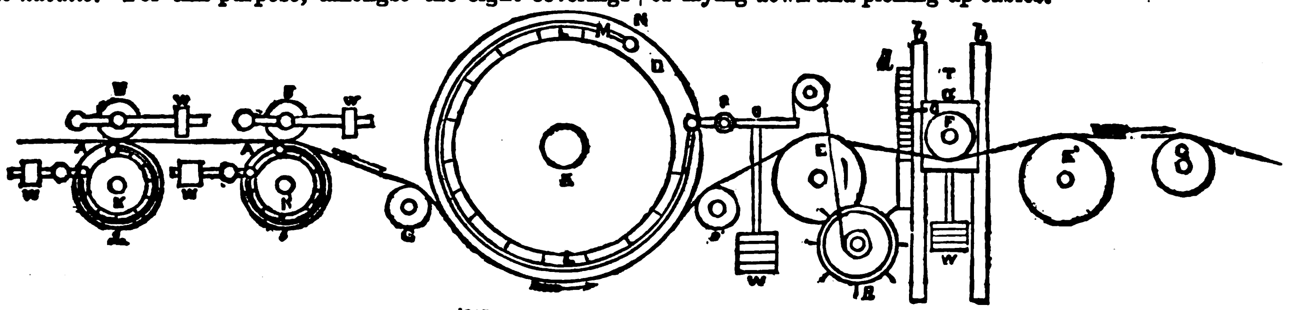
In our first number we stated that the Eastern Extension Company had just added the above-named vessel to the fleet of cable ships.

On Monday, 3rd inst., in response to the invitation of Mr. John Pender, as chairman of the company, a large number of scientific gentlemen and others interested in the cause of electrical progress proceeded by special steamer to Greenwich to inspect the *Sherard-Osborn* and the works of the company. The ship, fresh from the builders' hands, and gaily decorated with bunting in honour of the occasion, excited the unqualified admiration of her visitors, who were none the less pleased that her fittings throughout betokened that strength and utility had not been sacrificed for the sake of mere outward effect. Admirably adapted for the performance of her special duties as a cable ship, the *Sherard-Osborn* is, however, not lacking in the elements of comfort so necessary to those engaged in the arduous work of cable-laying in the burning climes for which she is destined. The four large tanks were as yet empty. At the works, however, to which the visitors next proceeded, the cable which is about to be embarked was rapidly approaching completion, so that the elaborate process could be examined in all its stages. The experience gained during the past few years has shown that the deep sea cable has many foes, and a new feature in the construction of the one destined to form the first cargo of the *Sherard-Osborn* had for its object the defeat of that most pertinacious enemy, the *teredo navalis*. For this purpose, amongst the eight coverings with which the precious copper is protected there has been introduced a wrapper of brass tape, and it is confidently anticipated that this final precaution will baffle even the *teredo navalis*.

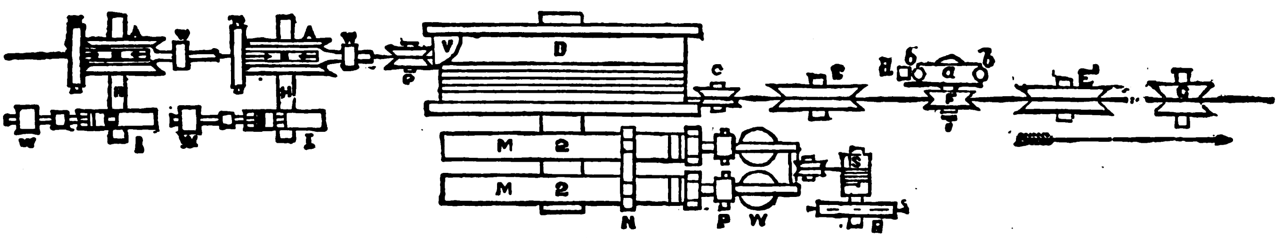
When everything of interest had been thoroughly inspected, the company adjourned to the Ship tavern, where covers were laid for 150 guests. Mr. Pender, as president, was supported by Sir James Anderson, Sir Garnet Wolseley, Sir Spencer Robinson, Mr. Hussey Vivian, M.P., Mr. Donald Currie, M.P., Sir Archibald Michie, Mr. E. J. Reed, M.P., Sir William Thomson, Mr. Julius Beer, &c., &c.

In returning thanks for the Army and Navy respectively Sir G. Wolseley and Sir S. Robinson enlarged upon the debt which either branch of the service owed to men of science, and especially to those who had devoted themselves to the development of the marvellous powers of electricity. Sir A. Michie expressed the obligations felt by the colonists of Australia and New Zealand to the telegraph engineers, without whose labours they could never have attained their present prosperity; and Mr. Donald Currie forcibly urged the necessity of completing our communications by telegraph with the Cape of Good Hope—a necessity brought home just now to the breasts of all Englishmen by the thought of the struggle now going on between our countrymen and their native foes, the vicissitudes of which only came to our knowledge after a lapse of three long weeks.

Mr. Saunders, the electrician of the company, has kindly supplied further information relating to the ship, together with such diagrams and explanations as, we think, will render clear to all our readers the machinery employed to perform the work of laying down and picking up cables.



SIDE ELEVATION



PLAN

The Ship.

The *Sherard-Osborn* is 270 feet long, 32 broad, and 23 deep. The twin screws are driven by engines of 900 horse power nominal. The registered tonnage of the vessel is 875 tons, the gross tonnage, however, is 1,429 tons. There are four cable tanks, and water-tight bulkheads allow water ballast to be used to counteract the loss of weight when paying-out cable.

The Paying-out Gear.

In putting the cable on board for laying, sufficient end having been left out for testing, the coiling is begun from the large diameter of the tank in the direction of the lay of the cable, the turns being placed close to each other until the eye is reached, the latter being generally about one-third of the diameter of the tank and made telescopic, so that it can be gradually lowered as the coil decreases during the progress of paying-out. Each layer is called a flake. The cable is not coiled back upon the eye, but is laid out diagonally on the top of the flake to the side of the tank, and then coiled back to the eye, and so on until the tank is filled.

In laying the cable, the end is brought over a wheel placed over the centre of the tank, and thence along troughs until it enters the paying-out machinery, then passing over the V wheels AA, under the jockey wheels BB, which run on the top of the cable, and by their weight press it into the grooves of the V wheels already mentioned, thus keeping up a slight strain on the cable before it passes on to the paying-out drum D, around which it takes four or five turns, over the wheel E, under the wheel F of the Dynamometer, over the wheel E', and finally over the stern wheel G into the sea.

On the shafts H H of the V wheels A A are fitted friction brakes 1 1. The paying out drum has also a double break 2 2. The breaks consist of iron wheels or drums K K K, the peripheries of which are broad and flat. Around these press segments of wood L L L affixed to the steel band M. One end of this band is fixed to the frame-work of the machine at N, and after passing nearly around the drum K is hinged to the lever O, the fulcrum of which is at P, and on the other end of the lever weights W are placed according to the amount of friction required.

Attached to the frame of the machine is a wedge-shaped piece of iron, fitting close to the circumference of the paying out drum, and called the fleeting knife, its use being to fleet the turns of the cable, so that there shall be a clear space for the cable coming on the drum, and thus prevent the turns overriding each other.

The description of the brake to the paying out drum D will apply to those for the smaller brakes to the V wheels A A. The amount of friction can be very nicely regulated by means of the wheel R, which has spokes similar to those of a ship's steering wheel, and to prevent heating by friction the brakes run in tanks filled with cold water. On the shaft is a drum S, around which the chain fastened to the end of the lever can be wound, thus lifting the weights and regulating the amount of friction. The man stationed at this wheel watches the indicator of dynamometer T, and lessens or increases the friction according to the amount of strain indicated. A similar arrangement is attached to the small brakes and jockey wheels, by which the jockeys can be lifted and the amount of the friction on the breaks regulated.

The dynamometer consists of the slide *a* carrying the wheel F and weights W working between the two uprights B B according to the amount of strain in cwts. on the cable as shown by the pointer *c* on the scale *d*.

The different parts of the paying-out gear are placed relatively nearer each other in the drawing than they are on board ship.

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this requiring to be noted more particularly in regard to the wheels E.E' and C T. It is of the greatest importance that a sufficient amount of slack be paid out to compensate for the inequalities of the bottom. Great attention must therefore be paid to the relative speed of the ship and that at which the cable passes overboard.

To enable the engineers to judge on this point a rotometer is attached to the main shaft of the paying-out drum, which indicates every revolution by striking a bell. Further, pointers on a dial show the total number of revolutions. The engineer, knowing what speed will be given to the ship by a certain number of revolutions per minute of her engines, and counting the number of revolutions per minute of the paying-out drum, the circumference of which he has accurately measured, is able to tell at once whether the relative speeds of ship and cable will give the proper amount of slack; if not, he either increases or diminishes the speed of the ship or the weights on the brakes of the paying-out drum. Sir William Thomson's wire-sounding apparatus enables soundings to be taken so quickly that it is of great service in laying cables; and lately during such operations one ship has proceeded in advance of the other for the purpose of taking soundings, which were at once telegraphed to the rear or paying-out vessel, so that the engineers on board the latter could regulate the amount of brake power necessary to ensure the proper amount of slack being allowed.

Diagrams of the picking-up gear, with the necessary amount of explanation, will be given in another paper.

THE MICROPHONIC PROBLEM.

BY J. LAISTER, M.S.T.E.

One of the chief fascinations possessed by the telephone is its exceeding simplicity. Everybody can understand it; most people can even explain the "transmitter," and only a few profess any doubt about the "receiver." With the microphone the case is otherwise. The inventor, though he gives a consistent and philosophical account of its history, is constrained to admit that he does not quite understand the outcome of it himself. The time indeed has not yet arrived for forming a judgment complete and accurate upon this latest marvel, and we shall not pretend to suggest a solution of our own.

The variety of forms which the instrument is capable of taking are, at the very outset, an element of perplexity. Some of them will bear a very obvious explanation, but others will not; and, on the whole, they give rise to misgivings that the secret of all alike is of a rather complex sort. We can sympathise with the practical mind which promptly, and a little hastily, adopts a simple in preference to a recondite explanation; and unquestionably there is good service done in directing closer attention to the homely phenomenon of "contact," which finds exclusive favour in some quarters, as sufficiently accounting for the microphonic performances. When we see, for example, such statements as that which appears in the *Nineteenth Century* for this month, that "the passage of sonorous vibrations along the wire thus gives rise to corresponding sounds emitted" (in the telephone), and generally all speculative suggestions which attach a peculiar property to the sonorous character of the vibrations in relation to the currents, we begin to feel the necessity for a little sober reflection based upon our everyday experience. Whilst, however, we think the acoustical explanation—if we may so describe it—is far beyond the requirements of the problem, we cannot accept the "contact" theory as wholly sufficient to solve it. Neither Professor Hughes nor Mr. Preece, who has expounded his views, is responsible for the misapprehensions which have got abroad. Yet there exists, notwithstanding the cautious language of these gentlemen, a tendency to run into two distinct lines of explanations, one referring the effects to simple contact, the other to some subtle relationship between sonorous waves and electrical impulse. Let us examine what special function these rival claimants perform in the operations now under consideration.

First of all, it is a fact of great importance for acoustical science that sonorous waves are now found to be powerful and far reaching to an extent not previously suspected. Secondly, there is the twofold discovery for the Electrician that certain materials are exceptionally sensitive to concussion, or heat, or whatever else may be found to account for it, in affecting their "resistance;" and that what appear to be causes of the very slightest kind have a prodigious effect upon the current. These facts, however, do not go to the root of the matter where we are seeking for an explanation. The two conflicting theories which have been advanced so far may, we think, be dismissed by a very simple experiment. A piece of metallised carbon on the one hand, and a vibrating rod on the other, may both be included in a closed circuit with a battery and telephone. It will be found that neither concussion nor vibration will produce the slightest variation in the current. It is noticeable, however, that, if the greatest care is not taken in making the junctions, the telephone will faithfully reproduce both the blows and vibrations. And here we come across that part of the problem which has been overlooked by those who favour contact exclusively, namely, that, although we get a reproduction of mechanical sounds under these conditions, we are not able to obtain perfect articulation. And this is true, more or less, when loose bodies, such as nails, are piled up together. If a great number are employed, their varying weight and the multitude of points of contact render the reproduction of modulated speech approximately possible. But to obtain it with the precision of the telephone—and with that of the microphone when adjusted for telephonic purposes—something more is needed than the mere multiplicity of contacts. We must have elasticity, not makes and breaks of contact, of longer or shorter duration, or of greater or less rapidity; a swelling and falling of the current is needed, and this, we think, has not yet been accounted for in the microphone. There is, in fact, the same difference between this instrument, as some people describe it, and its actual performance, that there is between Reiss's musical telephone and Bell's articulating telephone. It was Professor Bell who first realised the essential conditions to be fulfilled in order to reproduce articulate speech, and who found in magneto-electricity a force which would mould itself to the requirements; it is Professor Hughes who has discovered an artificial means of compelling voltaic electricity to yield the same results. By introducing between the two ends of the conducting wires a material of infinite variability of resistance, and which, for practical purposes, is vibratory, the last-named gentleman has enabled us to control and direct the current so as to give it that undulatory character which vocal imitation demands.

The question now arises, where must we look for the seat of this curious and altogether exceptional sensibility? Is it in the blocks or pencils of carbon themselves, or is it at the points of contact? As regards the acoustical sensibility of these objects, it can be shown, we believe, that their action is purely mechanical, and that the material employed has just as much to do with the result as the pine-wood sounding-board. Continued experiments with the microphone satisfy us that the reproduction of the "tramp of flies," and such like sounds, are due to motion quite as often as to sound. The microphone does *not* respond to all sounds; but it does unfailingly register all movement. Further, it can be proved that, so long as the *points of contact* are of suitable material, the rest of the combination may, for electrical purposes, be of any conducting material we please. Given, therefore, a nicely adjusted automatic commutator, its sensibility will finally depend upon the character of the points which touch each other. Here, then, comes the knotty question, what is it that is potentially so energetic at these points? That there must be contraction and expansion of some sort we know, from the undulatory character of the resulting currents; and, on the whole, the several stages which the discovery has gone through, suggest the theory that the parts in contact undergo friction or concussion when exposed to sonorous or mechanical vibrations which cause contraction and dilation of the molecules. Combustion, Prof. Bell thinks, has something to do with the operation; and unquestionably combustion does take place when two ends of a voltaic circle are linked by a piece of carbon. Moreover, substituting for the carbon any other material favouring resistance and combustion, we can always obtain a steady and fairly permanent spark; and the notable thing is that this spark displays extreme sensibility to every disturbance in its neighbourhood. The spark itself is, of course, a mere indication of the combustion going on; but one may fairly assume that when the spark flickers combustion has been interrupted, and the current, which is the prime cause of both, has been subjected to variation. From this point of view, therefore, the contacts regarded as seats of combustion seem to promise a more probable account of their great sensitiveness than they do if treated as mere points of concussion. Nor does any serious difficulty present itself in applying this explanation to cases where nails or other metallic contacts are exclusively used. At all such imperfect junctions where the current is abruptly arrested and has to make a fresh effort, a spark is generally perceptible, and combustion of metallic particles or of solid matter in the film of air intervening is usually alleged as the cause of it. Be this as it may, the true place of sensibility in this instrument is that which we know to be in a state of incandescence when the adjustments are light. Whether the explanation here hinted at will hold good for the microphone, adjusted firmly for speaking purposes, is, perhaps, to be questioned. The lightness of the material employed, and the fact that tinfoil—a most inelastic metal—interposed between the points does not affect the results, seem to tell against the theory of molecular contraction and expansion, whilst they do seem to favour that of intermittent combustion. Proof is still wanting; but we are nearing a solution when we boldly face the difficulties of the problem.

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THE ELECTRICIAN.

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We cannot undertake to return drawings or manuscripts, and must, therefore, request Correspondents to keep copies.

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NOTICE TO EDITORS.

We shall be happy to exchange with the Editors of Scientific journals who receive the first numbers of The Electrician.

Nous serons hereux de faire l'échange avec Messieurs les Rédacteurs des Journaux scientifiques qui recevront les premiers muméros de l'Electrician.

Es wird uns ein Vernügen sein mit den löblichen Redactionen der deutschen und anderen continentalen Journäle und Zeitscriften, denen die ersten Nos. des Electrician *zu Händen kommen möchten auszutauschen.*

I Signori Editori di giornali scientifici che riceveranno i primi numeri dell' Electrician *ci faranno cosa gradita accettando il cambio che loro offriamo.*

TELEGRAPH ROUTE TO AFRICA.

As it was the Mutiny which urged the completion of a telegraph route to India, so the Kaffir War has been teaching us the desirability of communication with the Cape of Good Hope, and our other young but vigorous colonies in South Africa. So much less is the present danger in that region, and so much more have we had to think about at home during the past year, that this matter has not attracted as much public interest and consideration as it deserves. It has, however, been recently mentioned in the House of Commons, and, as leading telegraph and shipowning companies have taken it up, we may expect before long to hear of something being done. The question, then, arises—what is to be done? And here we find two opinions, between which there is a whole continent of difference.

The Eastern Telegraph Company propose to take a cable from their line at Aden along the East Coast of Africa by Zanzibar and Mozambique to Natal, which is already in communication with the Cape; there might also be a branch to Mauritius and Réunion. It is confessed that this line is not likely for some time to pay its expenses, but, from the various governments concerned, subsidies may be hoped for to the amount of £35,000, and the growing trade of that part of Africa offers some favourable prospect of returns in the not distant future. Without the Mauritius branch, under four thousand miles of wire would be required, the expense of which would mostly come from other pockets than those of the British taxpayer. A land line has also been suggested as practicable, on which subject we shall have more to say before long. But, if a submarine cable were preferred, it would probably be as easily kept in working order as the line from Aden to Bombay, which has never been broken since it was laid down seven years ago, and in that time has cost only £15,000 for repairs.

Mr. Donald Currie, who has good reason to be interested in the matter, has expressed another view in a letter to *The Times.* While admitting the importance of a cable along the East of Africa, he seems to think that the West Coast should be first attended to, and if the Government, as is likely, will not go to the expense of laying a cable all the way, he suggests that at least the Cape might be brought within twelve days' communication from England by tapping the Brazilian line at the Cape Verd Islands and carrying a cable to Goree, at which point, instead of Madeira, the Cape steamers might call. But he thinks that the extension of the telegraph to all our West African settlements is much to be desired. This would take 6,000 miles of wire; or, if the line ran direct from the Cape Verds by Ascension and St. Helena to the Cape of Good Hope, it would be necessary to lay 4,500 miles in deep ocean and along the course of the trade winds, which would hinder its being repaired, but not its being destroyed.

The chief argument against the East Coast route is, of course, that in the event of a war with Russia, our communications with Aden would be endangered. Now, taking the commercial advantages of this route as apparent, and setting aside for the present geographical considerations, let us look this bugbear of war in the face and learn that, in the opinion of our best practical telegraphists, the fear of anything more than temporary inconvenience may be set aside. No doubt, we can readily imagine the scene of the disturbance being laid mischievously near the road of our wires, and an enterprising enemy would scarcely fail to attempt obvious means of annoying us. But our communication with the East, like the sacred shield of Rome, would be tolerably safe in its multiplicity. We have lines to Egypt, not only by our Mediterranean stations, but through France, Italy, and Greece. It is in the highest degree unlikely that all these lines would be cut at once, or that all these Powers would be unfriendly to us. But, supposing an interruption made, we have the means of bridging over the gap. From almost any point a swift despatch boat could in two or three days restore communication, unless indeed a European Socialistic Republic had conspired to blot us out of existence. At Gibraltar and Malta we could have cables and ships, which in a week or two might replace the broken links, or supply a substitute by some other route. Whatever a hostile fleet might be about, our navy would certainly not be idle, and the enemy would probably find it more costly than profitable to meddle with our cables.

But a cable on the West Coast of Africa would be as difficult to guard as to maintain. As things at present stand, Russian cruisers are more likely to be found there than in the Levant. And, if we will talk of eventualities, some Cassandras have hinted at the United States as a possible ally for that despotic power. It would be easier for them to cut our cable than to invent the phonograph. Nay, the one seaworthy ironclad which a petty South American Republic might be able to keep out of the hands of its creditors, would have a fair chance of doing us such a serious injury before her presence would be even suspected by the few craft which we should be able to keep scattered along this vast ocean highway. If, on the other hand, any Power were threatening our Eastern Empire, the whole road through the Suez Canal must needs be alive with our ships and men. It would be a desperate struggle that must call forth all our strength; and, if ever our navy became too much crippled to protect our communications with India, the time would have arrived when these communications could be of little use to us.

In the course of time we hope to see all these cables laid, just as we hope to see Sahara turned into a lake, an Academy of Electrical Science flourishing at Timbuctoo, and devoted Hottentot missionaries rebuking the sinners of Belgravia.

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Electricity is the youngest and not the least elastic of the sciences, and has yet enormous fields to cover. But, if one step must come at a time, we have shown the step which, in our opinion, should come next.

ON THE STUDY OF ELECTRICITY AS A PROFESSIONAL PURSUIT.

BY THOMAS T. P. BRUCE WARREN.

II.

In this paper I propose to deal more particularly with the erection and arrangement of testing rooms. I cannot help expressing my surprise at the great blank, on this matter, which is met with in the works which have recently been written on telegraphy, when we consider that it is the very starting point of electrical engineering. I do not suppose that any one, unless he is engaged in some commercial application of electricity, will go to the expense of building a suite of rooms for laboratories. I shall therefore give some of the methods in general use for obtaining firm supports, &c., for testing apparatus as well as the more extensive arrangemements which are necessitated in factories, cable ships, &c. The telegraphist is generally considered to be the monopolist of electrical energy; this is a great mistake, although the area of our profession is so extensive that we may be pardoned for the mistake. Electricity, next to steam and water power, is the most extensively utilised agency in our daily necessities. Electro-plating and typing, the regulation of timekeepers or clocks, therapeutics, lighting by electricity, mining, and many other important applications belong to the Victorian era. The first thing an electrician has to consider is the sources of electricity, and this necessarily leads us to the battery room.

The battery room should be sufficiently large to hold the greatest number of cells which may be required without crowding. The temperature should be kept as nearly as possible constant, so that the solutions may be maintained at an uniform degree of saturation; only sufficient light should be admitted to let us see easily what is going on. Gas light is not desirable in consequence of its producing changes of temperature, so that whatever is required to be done to the batteries should be finished off in daylight, and preferably a few hours before they are required for use. The room should be kept clean and dry, free from dust and fairly ventilated; under no pretence should lumber be allowed to find even temporary residence here. The spare materials, such as glass jars, copper, zinc, sulphate of copper, solder, mercury, and the other requisites, should be all kept in a suitable store room.

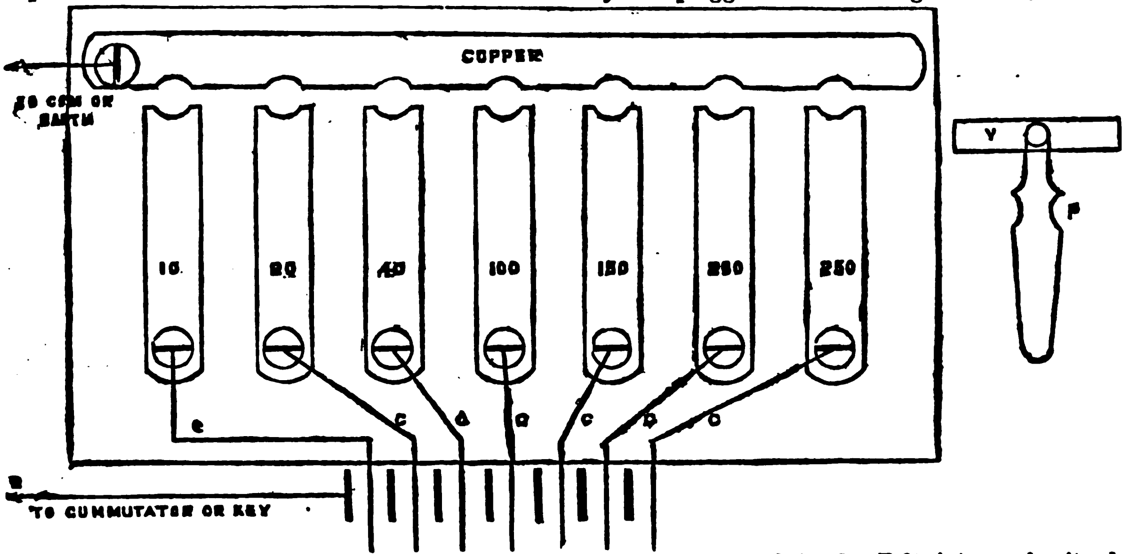
It is a great mistake to allow running in and out of a battery room while any testing is going on. A plan which I have generally adopted has been to have all the work which may be required finished off by a given time, the door locked, and the key handed over to the assistant in charge of the testing room.

At one time the form of battery usually employed for testing was the "gravity form" of Daniell's. On the underneath surface of the zinc a large accumulation of hydrogen took place, and the slamming of a door, or shaking of the shelves, was found to jerk these bubbles off; if a long length of core or cable was being tested at the time, this sudden escape of the gas became apparent by the great unsteadiness of the deflection on a galvanometer. Consequently, the battery shelves or racks should be rigidly fixed, in preference to being suspended, a plan which was recommended some few years ago with a view to securing a high degree of insulation.

In cleaning or replenishing batteries it is never prudent to rest satisfied if they give no trouble; the better plan is to take down a few sets of cells at stated times, examine them, and, if all is right, replace them. In this way the whole battery may be overhauled without producing any great changes in its electro motive force. Many electricians, I believe, prefer to renew their batteries entirely at one time, and I do not see any objection to this when the number of cells in use at one time is not very large; but it is evident that, in the case of batteries containing from 500 to 1,200 cells, and in the aggregate numbering about 4,000 cells fitted up at one time, such a method could not be adopted.

After the batteries have been inspected, and such cells replaced or replenished, as the case may be, a careful test is made, and, if satisfactory, the door is locked, and no one allowed to enter the battery room during the day but the assistant in charge and the battery man.

This necessitates the use of a "battery board" in the testing room, which is simply an insulated set of connections joined to different parts of the battery, so that any required number of cells may be "plugged in." See Diagram No. I.



This arrangement was, I believe, first suggested by Mr. De Sauty, and is so far beyond improvement that it has continued in use for several years. The leading wires C may be connected permanently to any or such portions of the battery which will give the most convenient number of cells that may be required. A conical plug P (of which there should be at least two) is inserted between the wire leading from C to the brass strip marked "copper." The wire marked Z leads to another terminal, the tension at which corresponds to the number of cells "plugged" to "copper" provided that no leakage takes place across any of the preceding terminal plates. Instead of connecting the terminal on the strip marked "copper" direct to the earth plate, it is more convenient to connect it to one of the terminals of a circular commutator, the terminal of the battery being connected to the same circular commutator. By this we can conveniently use either the zinc or copper pole of the battery, and employ any number of cells we wish by "plugging in" as before. The holes in the "battery board" are made conical, so that the plug fits thoroughly with a good grip.

The brass stem of the plug P fits into an ebonite shaft or handle V by being tapped or screwed, but the twist given to the plug so as to secure a tight hold tends to loosen it from its handle. A remedy for this was sought in drilling a hole through the brass and the ebonite, and inserting an ivory pin; but the disadvantage of the ivory pin was soon felt by the awkward shocks experienced when the fingers came in contact with it. Ebonite was subsequently used in place of ivory, but its brittleness rendered the plugs useless in a shorter time. The form of commutator which I designed, and which was slightly modified by the late Mr. Becker, combines everything which can be desired for convenience and certainty. The rubbing action of the contacts removes corrosion and secures a clean surface in all the connections. After being in use for some time, it will be best to remove the cover to see whether any metallic particles which may have been rubbed off by use require clearing away.

I have never seen one of these commutators give the least trouble, even after several years' use.

In the diagram the position of the handle and connections

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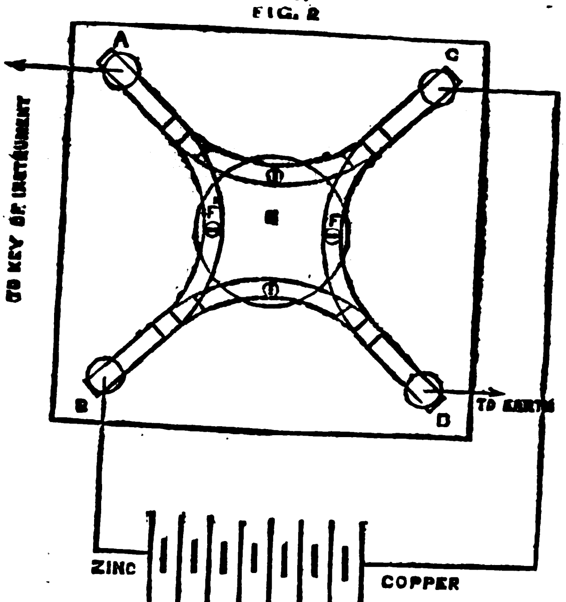
shows copper to earth and zinc force, which by half a turn of the handle will correspond to the dotted lines, zinc to earth and copper free.

Glass, earthenware, ebonite, and gutta percha are at present in use for battery cells. The trough forms of battery consist of boxes of teak or other wood divided into compartments by sheets of porcelain, glass, slate, &c. Glass has many qualities in its favour, especially when the battery is stationary, its first cost being little over that of earthenware, whilst its insulating property is considerably higher; it allows the contents of a cell being visible when in action, a quality which places it above any other material.

Electricians as a rule are not chemists, and consequently they cannot see that there may be much difference in the composition of glass. I would simply point out that one of the great difficulties which I believe is met with in the quadrant electrometers of Sir William Thomson, is due to the want of good insulating qualities in the glass used in their construction. I am investigating the effects of small quantities of accidental impurities in glass; and, so far as I am able to see at present, it appears that glass itself, which we are generally disposed to regard as being so permanent in constitution, is liable to singular changes under the action of time.

FIG. 2



The finest English white flint glass is the best adapted for battery cells, but, as this is much dearer than foreign white glass it is gradually falling out of use. The importation of foreign glass into this country for batteries has brought in that combatant spirit of competition which unfortunately results in the sacrifice of character rather than trade. Whether a glass cell be perfectly clear, and free from bubbles, specks, or clots, does not appear to be considered; we live in so utilitarian an age that we cannot stop to think of such trifles.

The cost of ebonite and gutta percha puts them out of consideration for ordinary use. Gutta percha for battery cells has never been much used; on the other hand, ebonite has been extensively employed, and is especially suited for any purpose to which glass is adapted, but where the risk of breakage precludes its employment. It is quite equal in insulation to the white glass now in use, it is not easily broken, and were it transparent, I believe that, in spite of its first cost as compared with glass, it would be the very best material for battery cells for whatever purpose they may be required. One great advantage they possess over glass, is that moisture does not condense on them so easily as on glass, unless the glass itself be first coated with paraffin or wax, which exert a repellent action to "wetting."

[TO BE CONTINUED.]

DIA-ELECTRIC.

BY ALEXANDER J. G. ADAMS, A.S.T.E.

During the early part of last summer, like many others, I put the telephone through a course of experiments; in this instance with the view to arrive at something definite as to the precise circumstances under which sound was reproduced at the receiving end of a telephonic circuit. Why? Because I had observed that, although a disc of the thinnest steel with a slice off the end of an iron bar at its centre afforded the best results for *sending*, it really mattered little what the receiving diaphragm was like, provided the sound was received from the telephone by a material conductor and not by the air. I had for receiving thick discs and thin bladder, or paper with iron at its centre, bladder sprinkled with iron-dust, and the flat end of a crowbar. There was a slight improvement with some over others in loudness or in sensitiveness, but in no case did mass at the receiving end appear greatly to affect the result.

How, then, was this sound produced? Authorities certainly differed, and still differ, upon the point; some thought it was the actual vibration of the diaphragm consequent upon magnetic attraction and repulsion. Professor Bell considered the effect as molecular; others thought it due to both, and, as I thought it due to neither, I set to work in my own way to settle it.

Amongst other experiments was one to ascertain the telephonic effect of magnetic surface; and the telephone magnet used had a flat iron disc at its pole equal in size to the thin iron diaphragm near it, and the latter was fixed at its centre to admit vibrations at its circumference. It happened that the helix made contact with the magnet, and the two ends of the secondary coil of the indicator, used to increase the effects, getting accidentally in contact, the one with the helix, the other with the diaphragm, the repetition of sound I had long vainly striven to obtain was emitted loud and clear.

Here was mystery; and mystery, that being followed up, led me far from the telephone. In fact, I had now two sound phenomena upon my hands instead of one. To what could this latter be due?

It was found that the nearer the discs approached each other the more intense became the sound, until touching, the insulation between them was destroyed and the sound ceased. It could not be a *magnetic* effect, for discs of any conducting material would act the same. And, moreover, upon placing two discs—one each side a third—that the respective effects might be neutralised, it turned out that the sound was nearly doubled in loudness rather than diminished (Fig. 1.) It appeared evident that

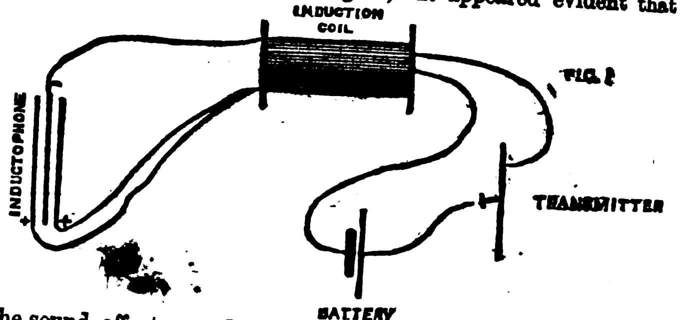


FIG. I

the sound effect was due to electrostatic induction, and to the arrangement was, consequently, applied the term *Inductophone*. Thus, if two sheets of tin foil were respectively connected to the ends of the secondary coil, and a tune played upon a telephonic transmitter in the primary circuit, that tune would be reproduced upon foils loud and distinctly. The foils, however, require to be insulated from one another by a sheet of paper or other di-electric, and pressed gently together. Sheets of damp paper insulated by gutta-percha have the same effect, provided the damp paper does not actually adhere to the insulating material; and, with great care and perseverance, sound may be—it has been—obtained from two opposing films of soap-water.

Months were spent in cogitation and experiment, during which it further transpired that, if any two electrified surfaces were brought near one another, with a film of air between them, sound could always be reproduced; but that, directly the air was excluded, no sound whatever could be obtained. Here was a hint, which, being acted upon, conclusively proved that these inductophonic sounds were the result of the electrification and consequent vibration of the air film. Thus, if two leaves of foil, insulated by percha, were placed under a press, clear sounds could be obtained until the press was forced home to the exclusion of the air. So, too, if upon the exterior sides of a thin flat cell lie pasted tin foils respectively connected to the inductor, so long as the cell contains air, sound is emitted, but directly the cell is filled with water sound ceases. If, however, two pieces of talc secured at their edges, so that they contain between their flat sides a film of air, be plunged into the cell of water, sound is again heard, but fails upon the withdrawal of the tales. (Fig II).

But more than this, if air is electrified by two opposed surfaces, why not by one? The experiment was tried, and it was found that the air is apparently more or less negative to one pole of the secondary coil; for, upon attaching that end of the coil to a metallic plate, to damp paper, or wood; or by dipping the end of the wire into an insulated glass of water, the ear placed near one of these charged surfaces easily detected the faint reproduction of sound emitted from it. Recently, a Hughes's transmitter

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or microphone has been placed upon a metallic body in connection with this particular end of the secondary coil, and the sound again reproduced upon a telephone. In this case the vibrations given to the microphone by the charged body are first developed

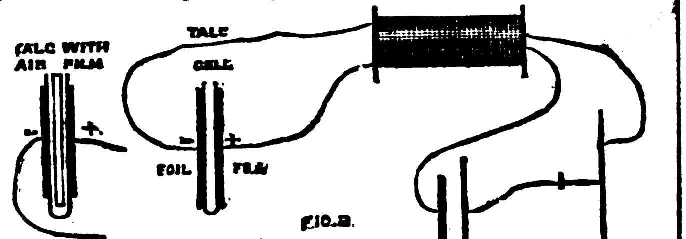

FIG. 2.

in that body by the air undulations beating against it. If, however, the charged body be carefully excluded from the air by being covered with some insulating material, no sound will be transmitted by the microphone.

Now, what may we deduce from these experiments? I think this—that we have here another addition to the already long list of electrical phenomena—*atmospheric dia-electricism*. Perhaps, too, many substances are subject to a similar peculiarity, whether the dia-electrical effect produced consists of a *like* or of but an *unlike* kind is uncertain.

Aided by the experience gained with my Inductophone, the old telephonic experiments were re-examined and new ones tried, and furnishing evidence to my own mind that just as Inductophonic sound undulations are due to the *dia-electric*, so the true telephonic sounds are based upon Faraday's dia-magnetism. Upon the latter theory, however, there are experiments still under attention, and their results for or against it I hope to give in another paper.

CORRESPONDENCE.

TIME SIGNALS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Having become one of your subscribers, I venture to suggest that some effort should be made to induce Government to reduce their exorbitant charges for time signals. If this were accomplished a great many public clocks would then be connected with Greenwich Observatory, which would, without doubt, prove of great convenience.

I am aware there are some mechanical difficulties to overcome, but they are not beyond the grasp of the electrical mechanist.

I am, yours truly, TIME SIGNAL.

(We have received a long communication relating to Sir James Anderson's article on "Practical Errors in Telegraphy," but the author deems it necessary to make some alterations; so that we are compelled to leave it over for another issue.—ED. *E.*)

RUSSIAN TELEGRAPHS.

An interesting *résumé* of the Russian telegraphic service has recently appeared in the *Moniteur des Chemins de Fer*, giving the details up to the end of 1876, the latest that have been made up by the Department. At the commencement of that year, the length of the telegraphic lines worked by the State was 61,287 versts (1 verst equals about 5¼ furlongs), with 118,299 versts of wire, while there were 778 telegraph offices. In the course of the year 22 new lines were opened, of the length of 2,973 versts, with 6,697 versts of wire, and 66 offices, of which 48 were in Russia in Europe, 8 in the Caucasus, and 11 in Russia in Asia. Twenty-one of these offices were on account of the war necessities. The lines worked by the railway companies in 1876 were increased by 652 versts, with 1,304 versts of wire and 130 new offices. The lines belonging to private companies have only undergone extension to the amount of 93 versts, comprised in the laying of the submarine cable between Finland and the Islands of Alsord, an undertaking which was carried out by the Northern Telegraph Company. On the 1st January last year, the total of Russian telegraphs were as follow:—

	Versts of line.	Wire.	Stations.
State network (reseau)	64,620	124,997	844
Railway	16,849	36,800	1,126
Anglo-Indian line	3,407	7,290	53
Submarine cable (Alsord Islands)	92	92	
Private lines	378	378	53
Miltary and police of the capitals	350	350	90
Total	85,696	169,907	2,166

At the close of 1876, the Administration employed 7,353 persons, viz.:—Central Administration, 201; mechanicians, 143; superintendents, 640; telegraph operators, 4,027 (620 women); messengers, porters, &c., 2,342. During the year 3,568,528 paid messages, 283,472 free messages, were sent in the Inland Department; 327,454 paid and 9,109 free were sent in the Foreign Department, which also received 324,860 paid and 12,069 free messages; while in the tourist service there were 74,412 messages sent—making a grand total of 4,599,904 messages for the year, an increase of about 10 per cent. over the year before. The following is a table of the proportion of messages from each country to Russia:—

	1876.	1875.		1876.	1875.
Germany	216,081	202,751	Denmark	10,146	9,070
Great Britain	117,591	113,007	Roumania	9,673	10,457
France	75,481	74,677	Switzerland	9,023	9,593
Austria	74,185	73,380	Servia	6,874	374
Sweden	26,799	27,995	Greece	2,994	2,305
Holland	24,063	22,907	Spain	2,187	1,247
Italy	22,234	22,769	Malta	971	1,293
Belgium	18,047	16,769	Portugal	624	744
Turkey	13,677	12,047	Montenegro	47	35
Norway	10,710	10,058			

As regards the Eastern nations, the particulars were:—

Persia	4,497	3,043	China	438	457
Turkey in Asia	3,581	3,670	India	111	177
Armenia	1,158	1,016	Algeria	75	94
Egypt	516	401	Australia	8	5
Japan	476	449	Arabia	7	1

There are only about 37 towns in Russia which do any foreign business by telegraph, and these do about 90 per cent. of the whole. For instance, St. Petersburg received 107,859 foreign messages; Moscow, 32,974; Odessa, 29,881; Riga, 24,595; Warsaw, 21,320. The gross receipts, which in 1875 were 4,863,336 roubles, rose in 1876 to 5,590,119—an increase of about 15 per cent. The expenditure in 1875 was 4,094,070 roubles, and in 1876, 4,500,505—an increase of 9 per cent. The average yield of the telegrams was 1 rouble 43 copecks (1 rouble equals about 3*s.* 2*d.*, 5 copecks equals nearly 2*d.*), and as the cost of the telegram was about 1 rouble 15 copecks, the Treasury gained 28 copecks by each message.

THE LAW OF INTERNATIONAL TELEGRAPH TRAFFIC.

It may, perhaps, aid in the discussion of telegraphic errors if we give the results of the investigation of Mr. Madsen, as stated by him in a recent paper to the Society of Telegraph Engineers. International traffic differs considerably from inland traffic, inasmuch as the greater number of international messages are purely commercial. Sir James Anderson first pointed this out, and Mr. Madsen correctly reasons, it seems to us, that international telegraph traffic must, therefore, bear some ratio to the commercial transactions between the different countries. He analysed seventy-seven groups of differently composed traffic between differently situated countries, and found the result in harmony with the empirical law.

$$T = C \left\{ \sqrt{V.\ N} + N_1 + N_2 \right\} \qquad (1)$$

When T denotes the number of telegrams.
" C " a variable co-efficient.
" V " value of trade, expressed in pounds sterling.
" N " tonnage of vessels engaged in the direct trade between the two countries L and L_1.
" N_1 and N_2 denote tonnage of vessels belonging to either of the countries L L_1, and engaged in the carrying trade L_1 and L.

The Commercial Factor $\left\{ \sqrt{V.\ N} + N_1 + N_2 \right\}$ expresses the total amount of commercial traffic, however it may be composed. The co-efficient C is variable, and expresses the ratio between the telegraphic and commercial traffic. Countries similarly situated have similar commercial relations, and hence similar telegraphic communications, and Mr. Madsen found that "the co-efficients are in inverse proportion to the distance between the countries, or, the telegraphic traffic between two countries is in direct proportion to the amount of commercial traffic, expressed in commercial units, and in inverse proportion to the distance between the countries." Thus C is composed of two factors, one constant, the other variable, and may be written $C = \frac{c}{d}$, when d is the distance, and c the variable element. Assuming unity to be equivalent to the means of international communication at the beginning of such communication, the accumulated progress at the end of N years uniformly divided gives the annual

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progress p. The *complete equation* at the time of n years after the introduction of the international telegraph is

$$T\,n = \frac{(100+p)^n}{100^n\,d}\left\{\sqrt{V.N} + N_1 + N_2\right\} \qquad (2)$$

If in this equation the progress p, or the time n, or both these factors $= 0$ we get the normal equation for the international traffic:

$$T = \frac{1}{d}\left\{\sqrt{V.N} + N_1 + N_2\right\} \qquad (3)$$

The average variation of the co-efficient is found to be about 4 per cent., and this irrespective of the annual progress in the commercial traffic. The general advance in the telegraphic traffic is therefore depending on the increase of *two* factors, and if, for a number of years, the augmentation in the value of these factors, p (progress) and n (commercial units) is found to be equal, then the telegraph traffic for the next period may be calculated to advance under similar circumstances according to the equation:—

$$T_{(1855\,\times\,n)} = \frac{(100+p)^{2n}}{100^{2n}\,d}\left(U_{1855}\right) \quad . \; . \; . \quad (4)$$

In this equation the period is reckoned to commence with the year 1855, the trade, navigation, &c., and the general condition of international intercourse for that year being taken as basis. The law of distance is the basis of the telegraph traffic-law as well as of all others.

A question which immediately presents itself is the question of the probable traffic on a proposed telegraph line, or on a line not fully developed. The equation (3) will answer this question, but it will require some local examinations before the value to be allowed the expression of $C = \frac{1}{d}$ can be settled. In an enterprise between remote and isolated countries, without any, or with only unimportant means of telegraphic and other communications, and but a small commercial traffic, the co-efficient can scarcely be expected to exceed the value of $\frac{1}{d}$; in other cases, where the countries are well populated, and commercially brought up to a "European" standard, the co-efficient may be taken equal to that of a fully developed traffic.

When the question is the tariff to be employed, upon which it chiefly depends whether an enterprise will pay or not, the proper tariff may be determined either directly or indirectly; in the first place, simply in proportion to the probable traffic and unit of tariff, and, indirectly, from analogically situated establishments. In this case the researches prove that the proportion between the tariffs, which are to pay the interest on the capital and the cost of maintenance and working, may be expressed as follows:—The normal tariffs are in direct proportion to the square of the distances and in inverse proportion to the number of commercial units.

STUDENTS' COLUMN.

NOTES ON STATIC ELECTRICITY.

BY O. LODGE, D.SC.

[The following notes were written out for the use of some students preparing for a Civil Service examination, and, as they embody in a compact form a selection from such well known facts as are often made use of for examination purposes, they have been found useful. I have, therefore, thought that they would be suitable for insertion in the Student's Column of *The Electrician*.—OLIVER J. LODGE, University College, London.]

Quantity of Electricity (Q or q) is measured by the force with which two quantities attract or repel one another. Coulomb's balance measures this force, and shows that it is—

$$F = \frac{q\,q'}{d^2}, \text{ or when the quantities are equal, } F = \frac{q^2}{d^2}$$

hence $q = d\sqrt{F}$ and the unit of quantity is that which repels a similar equal quantity at unit dist. with unit force.

Density (ρ) is the charge on unit area, $\rho = \frac{q}{A}$

The Potential (V) of a point is the work done in bringing a unit of positive electricity from infinity to the point.

The potential at a point distant r_1 from a body charged with q_1, r_2 from q_2, and so on, is $V = \Sigma\,\frac{q}{r}$. The electrical force at a point in any direction is the rate of variation of potential in that direction, or $\frac{d\,v}{d\,s}$.

The resultant Electrical force (F) at a point is the *maximum* rate of variation of potential there. It is the force with which a body charged with unit of positive Electricity would be acted on if placed at the point, provided it did not affect the previous charge in any way.

The force due to a single charge q at distance r is $F = \frac{q}{r^2}$. A line drawn always in the direction of resultant force is called a *line of force*.

A surface cut orthogonally by every line of force is called an *equipotential surface*.

Every point of such a surface is obviously at the same potential, and, if there be any charge on such a surface, it must necessarily be in equilibrium.

Any conducting shell on which electricity is at rest is necessarily an equi-potential surface; and lines of force extend from such a shell to neighbouring charges of electricity, whether these be inside or outside; *but the lines inside and the lines outside are wholly independent of each other*. If there are *no* charges inside, then there is no force, and the potential inside is constant: Lines of force proceed from external bodies to the surface and there stop.

If it be possible to arrange charges on points inside a closed conducting shell, so as to produce an internal set of lines of force entirely continuous with the lines of force outside, then the conducting surface may be removed without producing any disturbance; and the effect of the conducting shell upon bodies outside it is precisely the same as that of the charged points (which are called images).

A charged conducting sphere in space, for instance, has a uniform distribution of E, and therefore has its lines of force radiating out equally in all directions. But a point at its centre charged with the same quantity of electricity would have precisely the same lines of force. Hence a sphere acts on bodies outside it as if its whole charge were collected at its centre.

The potential at a point distant d from the centre of a charged sphere of radius R is $\frac{Q}{d}$ or $\frac{4\,\pi\,\rho\,R^2}{d}$; therefore the potential of the surface of the sphere (*i.e.*, of the sphere itself) is

$$V = \frac{Q}{R} = 4\,\pi\,\rho\,R$$

The Capacity (S) of a conductor is the ratio between its charge and the elevation of potential it produces; or $S = \frac{Q}{V}$

Hence the capacity of a sphere in space is simply the radius, S = R

When the sphere is contained in another concentric sphere charged with an independent quantity Q', and of radius R', the potential of the inner sphere (being equal to the potential at its centre) is $V = \frac{Q}{R} + \frac{Q'}{R'}$* Hence the capacity is now

$$S = \frac{Q}{V} = \frac{Q\,R\,R'}{Q\,R' + Q'R}$$

If the outer sphere be connected to earth Q' equals simply Q, so that S becomes $\frac{R\,R'}{R'-R}$† this becomes R when $R' = \infty$. When $R' - R = t$ and is small, S becomes $\frac{R^2}{E} = \frac{A}{4\,\pi\,t}$.

The force at a point distant d from the centre of a sphere is

$$F_1 = \frac{Q}{d^2} = \frac{A\,\rho}{d^2} = 4\,\pi\,\rho\,\frac{R^2}{d^2}.$$

Hence at the surface it is $F = 4\,\pi\,\rho$. This, then, is the electrical force just outside a sphere charged to density ρ.* Consider the point P just outside a sphere, also the point Q just inside. Draw a plane through Q normal to PQ, it cuts off a bit AB of the sphere which is practically plane. Now, as there is no force in Q, it follows that the effect of the area AB is numerically equal to the effect of the rest of the sphere ADB. But the effect of the whole sphere on P (close to Q) is $4\,\pi\,\rho$; therefore the effect of AB or of ADB is $2\,\pi\,\rho$.

So the force just outside a plane area charged on *one side* to density ρ is $2\,\pi\,\rho$.

Hence also the force just outside any elementally flat closed shell whatever, at a point where the density is ρ is $4\,\pi\,\rho$, for from

† If the capacity be reckoned as between the inner and outer spheres instead of between the inner and the earth—*i.e.*, if S be reckoned $= \frac{Q}{V - V'}$ instead of $\frac{Q}{V}$, then, since $V' = \frac{Q' + Q}{R'}$, S will always be $\frac{R\,R'}{R' - R}$ whatever Q may be.

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it also may be cut off a small portion which balances the force of all the rest at a point close to it.

The force *on* AB itself is the force due to ADB, which is $2\pi\rho$ per unit of its charge; but its whole charge is $a\rho$ (a = area). Hence the whole force on it is $2\pi\rho a\rho$; or the force on unit is $2\pi\rho$. This is called *tension*. It is the force with which E tends to escape from a conductor.

Since there is no force inside any closed shell, it follows that the part most distant from a central point (*i.e.* the projections) must have most electricity on them to make up for their distance, and as the tension varies with the square of the density, the tension on the projections is much greater than at other places.

To find the capacity of any condenser between the plates of which the force is constant, such as two parallel discs very near together.

Area of each = A. Distance apart = l. Let one be in insulated and charged with quantity Q to density ρ and potential V, and let the other be connected to earth, so that its potential is O and it density $-\rho$. The force at any point between them is $2\pi\rho-(-2\pi\rho)=4\pi\rho$, and it is also equal to the rate of variation of potential $\frac{dv}{dt}$, which is constant and equal to $\frac{V-O}{t}$

Hence $V=4\pi\rho t$ and $Q=a A\rho$ $\qquad S=\frac{Q}{V}=\frac{A}{4\pi t}.$

* Figures will be inserted with continuation.

[TO BE CONTINUED.]

ANSWERS TO QUERIES.

9. There are several little pamphlets published on the telephone, one of which, "The Telephone and Phonograph," published by Messrs. Tegg, seems fairly popular and correct. "F.W.J." will get similar pamphlets at almost any bookstall. Prescott, in his admirable book on Electricity, devotes some pages to the discussion of the question. "F.W.J." should understand that at present the phonograph is a mechanical and not an electrical instrument. J. DAVIS.

LITERATURE.

The Telephone and Phonograph: a Popular Account, Scientific and Mechanical. William Tegg and Co.—This handy little book is part of a larger work on "Posts, Telegraphs, and the Telephone," compiled by William Tegg. It seems well adapted for giving a general notion of these recent inventions which are in all the world's mouth at present; and we would only urge the publisher to bring the next edition up to date by a supplementary chapter on the microphone. The part to which the idle reader will turn first is prefaced by a sketch of the History of Electricity. In stating the present position of the science, the common doctrine that "both electricity and measure are but forms of motion" should not have been given without the remark that there are still eminent electricians far from convinced on this point. With this one exception we have nothing but commendation for Mr. Tegg's well-timed account of the phenomena which were being turned into such fun by the comic papers only the other day.

THE PHYSICAL SOCIETY.

PROFESSOR HUGHES ON THE MICROPHONE.

A general meeting of this society was held on Saturday, the 8th inst., at the Science School, South Kensington, under the presidency of Professor Adams, F.R.S.

The SECRETARY having read the minutes of the last meeting,

The CHAIRMAN signed them, and subsequently intimated that with regard to the day of meeting, although there was a small majority in favour of change, the Council considered that there was not a sufficient majority to justify them in making such a change in the time of the meeting. The day of the meeting would, therefore, still be Saturday, at three o'clock. Continuing, he said he was glad that Professor Hughes was among them that day, and he would give them a communication on the microphone. He requested the secretary to read the communication.

Mr. ROBERTS accordingly read the paper, which was entitled "*Physical Action of the Microphone.*" It was very frequently applauded by a large and attentive audience. In the course of the paper the author pointed out that he would assume that some of the forms (of microphones) and the results produced were already known, and he would therefore confine himself to general considerations. The problem which the microphone resolves is this: introduce into an electrical circuit an electrical resistance, which resistance shall vary in exact accord with sonorous vibrations, thus producing an undulatory current of electricity from a constant source, whose wave length, height, and form shall be an exact representation of the sonorous waves. In the microphone they had an electric conducting material susceptible of being influenced by sonorous vibrations, and here they had the first step of the problem. The second step was one of the highest importance; for it was necessary that the electrical current flowing at this point should be thrown into waves of determinate form by the sole action of the sonorous vibrations. This the author resolved by the discovery that when an electric conducting matter was in a divided state, either in the form of powder, filings, or surfaces, and put under a certain slight pressure—far less than that which would produce cohesion, and more than would allow it to be separated by sonorous vibrations—the molecules in presence at these surfaces, being in a comparatively free state, although electrically joined, did of themselves so arrange their form, their number in contact, or their pressure (by increased size or orbit of revolution) that the electrical resistance of the circuit was increased and decreased in a remarkable degree. The problem being resolved, it was only necessary to observe general considerations to produce an endless variety of microphones, each having a special range of resistance. The tramp of a fly or the cries of insects required little range, but great sensitiveness. Here two surfaces of chosen materials under a very slight pressure, such as the weight itself of a small superposed conductor, suffered, but it would be unsuitable for a man's voice—the vibrations would be too powerful, and go far beyond the range allowed, producing interruptions of contact known as make and break. A man's voice required four surfaces of pine charcoal [as described in the author's paper to the Royal Society], six of willow charcoal, eight of boxwood, and ten of gas carbon. The effects were far superior, however, with the four of pine than the ten of gas carbon or any other material as yet used, fine wood being the best resonant material we possess, and it preserved this structure and quality when converted into the peculiar charcoal which the author had discovered and described. It was only necessary to have a certain number of surfaces and materials in accordance with range and power of vibrations, but they must be put under more or less pressure, in accordance with the force of the sonorons vibrations. Thus, for a man's voice the surfaces were under a far greater pressure than for the movements of insects. Still, the range of useful effect was very great, as the boxes which the author had specially arranged for a man's voice were still sensitive to the tick of a watch. In all cases it should be so arranged that a perfect undulatory current was obtained from the sonorous vibrations of a certain range. Thus, when speaking to a microphone transmitter of human speech there should be no deflection (while speaking) of a galvanometer placed in the circuit; and there should be observed no deviation whilst speaking, as the waves *plus* and *minus* of electricity were equal and too rapid for the needle to move. A general weakening or strengthening could only be recorded. If the pressure on the materials was not sufficient they would have a constant succession of interruptions of contact, and the needle of the galvanometer would at once register the fact. If the pressure was gradually increased from a weak pressure to a great they would have loud tones, but wanting in perfection, the galvanometer indicating interruptions. As the pressure was increased the tone became clearer, the galvanometer stationary, and a point of maximum loudness and clearness was attained. If the pressure was still increased the sounds became weaker, though very clear, and as they increased the pressure the sounds died out, as if a person was talking and walking away from them at the same time. Thus a point was soon reached at which there was complete silence. When attached to a resonant board the lower contact should be attached to a board, so that the sonorous vibration acted directly on it. The upper contact where the required pressure was applied should be as free as possible from the influence of vibrations except those directly transmitted to it by the surfaces underneath. The upper surface should have its inertia supplemented by a balanced weight, it being necessary with powerful vibrations to keep the contact unbroken. No spring could alone supply the required inertia, but an adjustable spring might be used, to insure that the requisite contact (of the balanced lever) was maintained. The contact might be maintained by an insulated screw, thus doing away with the lever and spring, but it was far more difficult to adjust, and the expansion by heat of the screw caused a varying pressure. It was exceedingly simple, however, easily made and illustrated the theoretical conditions better than the balanced lever which the author adopted in practice. In order to study the theoretical considerations, with the most simple form, freed from all surrounding mechanism, let a flat piece of charcoal be taken two milimetres thick, one centinetre square, and after making electrical contact by means of a copper wire on the lower surface, glue it to a small resonant board, or better for the purpose of observation, a block or cube of wood ten centimetres square. Upon this, superpose one or more similar blocks, the upper surface in communication with a wire, the lower resting flat, or as nearly so as possible, on the lower block. The required pressure was put on the upper block, then the two might be fastened together by glue at the sides or by an insulated screw. The pressure could then be removed, as the screw or glue equally preserved the force. Let them call the lower piece A, the upper B. When they put this block or board under sonorous vibrations they could not suppose an undulatory movement of the actual wave length in such a mass; that was a length comparable with the real wave length of the sonorous wave, which might be several feet. And they could not suppose a wave of any length without admitting that the force must be transmitted from molecule to molecule throughout the entire length. Thus any portion of a wave of which this block represented a fraction must be a molecular activity. The lower portion of the charcoal A being part of the block itself had this molecular action throughout, transmitting it also to the upper block. How was it that the molecular action at these two surfaces A and B should so vary the conductivity or electrical resistance as to throw it into waves in the exact form of the sonorous vibrations? It could not be because it threw up the upper portion, making an intermittent current, because it was fastened to the lower, and the galvanometer indicated no interruption of current whatever. It could not be because the molecules arranged themselves in stratified lines, becoming more or less conductive, as then they would not require surfaces (that was, there need not be discontinuity between the blocks A and B); nor would the upper surface be thrown up if the pressure was removed, as sand was on a vibrating glass. The throwing up of this upper piece B when the pressure was removed proved that a blow, pressure, or upheaval of the lower portion took place, and that this took place there could not be any doubt, as the surface, considered alone, having no depth, could not bodily quit its mass. In fact, there must have been a movement to a certain depth, and the author believed from numerous experiments that the whole block increased and diminished in size at all points, in the centre as well as the surface, exactly in accordance with the form of the sonorous wave. Confining attention, however, to the parts A and B—How could this increased molecular size or form produce a change in the electrical waves? This might happen in two ways. First, by increased pressure on the upper surface from its enlargement, or second, the molecules themselves, finding a certain resistance opposed to their upward movement, spread themselves, making innumerable fresh contact points;

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thus an infinity of fresh contacts or decrease in the number appeared to produce an undulatory current. The author was inclined to believe both actions occur, but the latter seemed to him the true explanation, as if the first was alone true there would be a far greater effect from metal, powder, carbon, or some elastic conductor, as metalized silk, than from gold or other hard inoxydizable matter; but, as some of the best results as regarded the human voice were obtained from two surfaces of solid gold, the author viewed with more favour the idea that an infinity of fresh surfaces, and *vice versâ*, brought into play by the molecular pressure, was the true explanation, and it had the advantage of being supported by the numerous forms of microphones which he had constructed, in all of which this effect can be fully traced. The author had been as much struck with the great mechanical force executed by this uprising of the molecules under sonorous vibration. With the musical vibration from a large musical box two feet in length, he found that one ounce of lead was not sufficient on a surface one centimetre square to keep it in constant contact, and it was only by removing a musical box several feet distant that he was enabled to preserve continuity of current with a moderate pressure. The author had spoken to forty microphones at once, and they all seemed to respond with equal force. Of course, there must be a loss of energy in the conversion of molecular vibrations into electrical waves, but it was so small that he had never been able to measure it with the simple appliances at his disposal. He had examined every portion of his room—wood, stone, metal, in fact, all parts, even to a piece of india rubber—all were in molecular movement whenever he spoke. As yet no such insulator for sound, as gutta percha for electricity, had been found. Caoutchouc seemed the best, but he had never been able by the use of any amount at his disposal to prevent the microphone reporting all it heard. The question of insulation had now become one of necessity, as the microphone opened a world of sound, the existence of which had not been suspected. If it could be insulated, so that its powers could be directed on a single object, as could now be done on the movement of a fly, it would be possible to investigate any desired object undisturbed by the pandemonium of sounds which at present the microphone revealed. However simple the microphone might appear at first glance, it had taken many months of unremitting labour and study to bring it to its present state through the numerous forms, each suitable for a special object. The field of usefulness for it widened each day. Sir Henry Thompson had succeeded in applying it to surgical operations of great delicacy; and by its means splinters, bullets—in fact, all foreign matter—could at once be detected. Dr. Richardson and the author had been experimenting on lung and heart diseases, and although the application by Sir Henry Thompson was more successful, it was probable that they would ultimately succeed. There was hope also that deafness might be relieved. For telephony, articulation had become perfect, and the loudness had been increased. Duplex, multiplex telegraphy would profit by its use, and there was hardly a science which would not be benefited where acoustics had some direct or indirect relation; and the author was happy in being able to present this paper on the results obtained by a purely physical action to such an appropriate and appreciative body as the Physical Society of London. In conclusion, he stated that throughout the whole of his investigations he had used Professor Bell's wonderful telephone as a receiver, and that it was owing to the discovery of such an admirable instrument that he had been enabled to commence and follow his researches.

Professor HUGHES subsequently demonstrated various forms of his wonderful, but extremely simple-looking instrument, pointing out the peculiarities of each. He observed that new and important experiments were found every day. He referred to Sir H. Thompson's recent delicate surgical operations, and exhibited a model of the instrument used by Sir Henry—a probe for detecting bullets or stone. Taking a piece of gloveskin, "to represent soft flesh," he put a bead in it, inserting the probe, and moving it around, taps were distinctly heard each time the bead was struck. He then placed in his hand a shot of the smallest number made, and a tap was also heard in this case each time the shot was touched. Professor Hughes also indicated an arrangement for relaying the human voice when transmitted through the telephone.

A short discussion ensued, in which the president, Professor Carey Foster, Mr. Waylen, Mr. W. Chandler Roberts, and other gentlemen took part; and Professor Hughes, at the close of the discussion, replied to several questions which were asked, observing in doing so that he was sure that every one who worked with the microphone would find more and more wonders.

The CHAIRMAN said they had heard a most interesting paper and discussion, and a number of questions had been asked, to which Professor Hughes had returned very satisfactory answers with regard to the microphone. He, therefore, asked them to give a hearty vote of thanks to Professor Hughes.—The request was enthusiastically acceded to.

TELEGRAPH SHARE LIST.

Amount of Issue.	Amount of Share.	Paid on Share.	COMPANY.	Reserve as per last Report.	Dividends 1875. %	1875. %	1876. %	1876. %	1877. %	1877. %	When Payable.	Prices 1875. Highest.	1875. Lowest.	1876. Highest.	1876. Lowest.	1877. Highest.	1877. Lowest.
£3,254,580	Stock	100	PAnglo-American	Deferred receiving no dividend until 6 per cent. has been paid to Preferred.	5	year.	5	4†	3	5	† Div. 5 % per ann. for quarter ending Dec. 31, 1876, 2% for quarter ending Mar. 31, 4 % for quarters ending June 30 and Sept. 30, 6 % for quarter ending Dec. 31, 1877, and 4 % for quarter ending March 31, 1878.	51½	75½	53	68½	52	62¼
1,872,710	Stock	100	Do. Preferred B		—	—	10	2	6	6		Crtd	1876.	75	93	79	88½
1,872,710	Stock	100	Do. Deferred A		—	—	Nil.	6	Nil.	4		Crtd	1876.	29	44	25½	38
1,300,000	10	All	Brazilian Submarine	120,000	5	5	5	5	5	5	Quarterly.	6	7¾	5¾	7¾	5⅞	6⅜
160,000	10	All	Cuba (Limited)	—	—	—	—	—	—	—	——	—	—	—	—	—	—
60,000	10	All	Do. 10 per cent. Preference	—	—	—	—	—	—	—	——	—	—	—	—	—	—
116,379	10	9	Direct Spanish (1)	—	—	—	—	—	—	—	——	—	—	—	—	—	—
58,430	10	All	Do. 10 per cent. Preference	—	—	—	—	—	—	—	——	—	—	—	—	—	—
65,000	20	All	Direct United States	Nil.	—	Nil.	Nil.	Nil.	Nil.	5	Quarterly.	7	13	6¼	11½	9½	13⅜
369,700	10	All	Eastern (Limited)	110,000	5	year.	5	5	5		aJany., April, *July*, Oct.	6⅝	8	5	7⅛	6⅝	8¼
1,997,500	10	All	Eastn. Exten. Australasia & China	125,404	5½	year.	5	year.	5	year.	aJany., *April*, July, Oct.	7	8¼	5⅛	7½	6⅞	8
232,000	100	All	Eastern 6 per cent. Debentures	—	—	—	—	—	—	—	——	—	—	—	—	—	—
200,000	100	All	Do. 5 per cent. Debentures	—	—	—	—	—	—	—	——	—	—	—	—	—	—
700,000	10	All	Do. 6 per cent. Preference	—	—	—	—	—	—	—	——	—	—	—	—	—	—
320,000	100	All	Eastn. Exten. 6 p.c. Deben. (1875)	—	—	—	—	—	—	—	——	—	—	—	—	—	—
192,680	10	All	German Un. Tl. and Tst.	—	—	—	—	—	—	—		—	—	—	—	—	—
1,500,000	10	All	Globe Telegraph and Trust	Nil.	5	7 4-5	4½	7 5-6	3⅜	7 6-7	bJany., April, *July*, Oct.	5⅛	6¾	4¼	5⅞	4¼	5¼
1,500,000	10	All	Do. 6 per cent. Preference		6	6	6	6	6	6	Jany., April, July, Oct.	9¾	10½	9¼	10⅛	9¼	10½
150,000	10	All	Great Northern Shares to Bearer, or can be Regstrd.	85,543	5⅝	year.	6⅝	year.	6⅝	year.	5 % intrm. Jan. 1, July 1. Final Dividend April.	7½	11½	7	9¾	7	8
—	25	All	Indo-European	—	—	—	—	—	—	—	——	—	—	—	—	—	—
120,000	10	All	Mediterranean Extension (1)	—	—	—	—	—	—	—	——	—	—	—	—	—	—
32,000	10	All	Do. 8 per cent. Preference	—	—	—	—	—	—	—	——	—	—	—	—	—	—
—	18	All	Reuter's (Limited)	—	—	—	—	—	—	—	——	—	—	—	—	—	—
65,000	10	All	West India and Panama	16,000	Nil.	Nil.	Nil.	Nil.	1	1		1⅜	4¾	⅝	2½	1⅝	3⅝
34,563	10	All	Do. 6 per cent. Preference		7/6ac	year.	10/ac	year.	6‡	6	‡ Converted from a 10 % into a 6 % 1st Preference.	9	12	7	11	7½	11
67,500	20	All	Western and Brazilian	7,793	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Half-yearly.	9½	18¼	4¼	10⅝	4½	5¾
$1,500,000	$1000	All	Western Union Telegraph 7 per cent. First Mortgage Bonds	—	7	7	7	7	7	7	May, November.	102½	108	105	109¼	106	113
£1,030,000	200	All	Do. 6 per cent. Sterling Bonds	Redeeemable by annual drawings at par.	6	6	6	6	6	6	March 1, September 1.	86	93	89	98	94	101

a Year ends March 31st. Interim Dividend of 5 per cent. Final dividend in July.

b Year ends July 18th. Final dividend in July.

SHRS.	PD.	COMPANIES.	BUSINESS DONE. Th., 6.	F., 7.	S., 8.	M., 10.	Tu., 11.	W., 12.
Stk.	100	Ang-American (1)	62¼, ½	—	—	—	—	62¼
Stk.	100	Do. Preferred	92⅝, ½	92⅝, ¼	92⅜, ¼ 2	—	92⅜, 2	92¼
Stk.	100	Do. Deferred (a)	—	—	—	—	35¼, 5	—
10	All	Brzn-Submarine..	—	6⅞, 7	7	—	7	—
		Do. 10 p. c. Pref..	16⅜	—	—	—	—	—
		Direct. Spanish (1) Submarine	—	—	—	—	9½	—
			—	—	—	—	223, 4	—
20	All	Dct. U.S.Cable (1)	13¾	13¾, ⅝	13¾	—	13¾, ⅝	—
10	All	Eastern (Lmtd.)	7⅝, 11-16	9-16 7 9-16	7⅝, ½	—	7 9-16, ½	7 9-16, ½
10	All	Do. 6 p. c. Pref...	—	—	—	—	—	11⅛
10	All	Estrn. Ex., Aus., and China	—	—	7⅞, ¾	—	7¾ 11-16,	7 11-16
		D. 6 p. c. Deb.	106½, 8¾	—	108, ¼	—	—	107½
10	All	Globe Tl.&Tst.(1)	5 5-16	5 3-16	5¼ 5-16	—	—	—
10	All	Do. 6. p. c. Pref..	10¾, ⅞	10¾, ⅞	10⅝, ¾	—	—	10⅜
10	All	Great Northern..	8½ 11-16,	8 11-16	8¾ 11-16	—	8½	8½

SHRS.	PD.	COMPANIES.	BUSINESS DONE. Th., 6.	F., 7.	S., 8.	M., 10.	Tu., 11.	W., 12.
10	All	W.India &Pan.(1)	2¼	—	—	—	—	2 3-16, 5-16
10	All	Do.6 p. c. 1st Pref.	—	—	8¾	—	—	—
20	All	*West. & Braz.(1)	5¼,	5¼	5⅛	—	5⅛ 1-16	—

(a) Deferred receiving no div., until 6 p. c. has been paid Preferred.

TRAFFIC RECEIPTS.

Brazilian Submarine Company (£90,000)—May, 1878, £12,564; May, 1877, £12,378.
Cuba Submarine Company (£16,000)—May, 1878, £3,500; May, 1877, £4,109.
Direct Spanish Company (£13,000)—May, 1878, £817; May, 1877, £972.
Eastern Company (£369,700)—May, 1878, £33,650; May, 1877, £46,309.
Eastern Extension Company (£199,750)—May, 1878, £23,844; May, 1877, £25,445.
Great Northern Company (£125,000)—May, 1878, £19,463 (for five months ending May 31st).
West India Company (£88,320)—May, 1878, £2,915 (for half month ending May 31st): May, 1877, £3,532.

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NOTES.

Private Enterprise.—Mr. Cunliffe Brooks, of the Old Bank, Blackburn, has obtained permission to lay a telegraph wire between the bank premises and the police station.

Telegrams for the West Coast of South America.—Notice has been received that the mail steamers, by which telegrams for places on the West Coast of South America are conveyed from Panama, now leave Panama for Lima on the 10th, 15th, 24th, 27th, and 30th of each month.

Telegraphy in Europe.—In 1876 there were altogether 217,962 miles of telegraph line in Europe. The aggregate length of wire was 647,096 miles, and the number of offices was 27,286. The number of messages forwarded during the year was 81,697,981. The corresponding number in 1875 was 77,847,955.

Numerical Value of the Constants in Weber's Formula.—W. Voigt, in a mathematical paper, proves that the ratio between the mechanical unit and the electro-magnetic unit is I : 155,570·10^6 instead of I : 155,370·10^6; and that the constant C of Weber's formula is 440,010·10^6 mm. instead of 439,450·10^6 mm.

Smithsonian Institution.—At a special meeting of the Board of Regents of the Smithsonian Institution, Professor Spencer Fullerton Baird, for many years the assistant secretary of the institution, was elected as the secretary of the Smithsonian Institution, to succeed the late Professor Joseph Henry.

The Telephone in Use.—The telephone has been successfully adopted, we understand, by the Central Pacific Railroad, as a means of communicating between stations over the mountain division. Boxes are to be placed a few miles apart, and the track walkers are required to report by means of them on each round. For use at stations where business will not justify the employment of a telegraph operator there is no doubt that the telephone will prove a valuable adjunct, and we expect to hear of its common adoption.

Electrolytic Deposition of Nickel.—The objects on which the nickel is to be deposited must be carefully cleaned and placed in a bath containing one part of the double sulphate of nickel and ammonium to twenty parts of water. The nickel salt must be pure, and also the nickel anode, which should not be smaller than the article to be plated, and a strong current should be used. If the bath gets acid it must be neutralised by the addition of dilute ammonia. In plating copper articles, the bath should contain one part of ammonium chloride to 100 of the nickel salt.*

The Telephone and Deafness.—Acting on a communication in *Nature* from Mr. Severn, Mr. John Browning describes a method of applying the telephone to make deaf people hear. He fastened a string to a parchment diaphragm of a simple telephone, made of wood, and carried this string round the forehead of the deaf person, who clasped it with both hands, and pressed them over his ears. The experiment was partially successful, the sound of the voice being always heard, and some words distinguished. Afterwards, he fastened a simple string to the telephone, and made the deaf person hold it between his teeth. Every word was then heard distinctly, even when spoken in a low tone at the other end of the room.

Gallium.—M. Jules Regnault has shown, in several communications to *La Nature*, that different fluid amalgams possess different degrees of electro-motive force, and he does not hesitate to attribute this fact to the unequal value of their specific heat. A striking demonstration of this truth is afforded, he now announces, by gallium, which, as is known, possesses this remarkable property of remaining liquid by *surfusion* at the ordinary temperature. M. Regnault composes a little battery in the following manner:—A strip of gallium in the solid state is covered with a leaf of paper impregnated with a solution of sulphate of gallium, and on it is placed a small drop of *surfused* gallium. Communication being established with a galvanometer, the liquid metal is observed to be attacked, that, namely, which has the highest specific heat.

The Delay of Telegraph Messages in the Metropolis.—The *Globe* has opened a correspondence, complaining of the unsatisfactory state of the telegraphic system in the metropolis. It is said that a message can often be sent more quickly by hand than by telegraph. This, of course, refers only to short distances, and, in other respects, the grumbling of the *Globe's* correspondent seems a little exaggerated. Only the excited feelings of a paterfamilias, disappointed of the salmon sent for by telegraph for his dinner, can justify the assertion that a "paternal government considers a mile an hour a fair speed for telegraphic messages to travel at within the metropolis." Still, it must be admitted that there is some cause for dissatisfaction, both as regards speed and price; and an official department, which is also a monopolist, would be more than mortal, or, at least, more than British, if it did not require stirring up from time to time.

Galvanic Current Between Solutions of the same Substance of Different Degrees of Concentration.—J. Moser has observed that, in a couple formed by the same liquid of different degrees of concentration, a current passes from the more dilute to the more concentrated solution, the liquids being in separate vessels connected by means of a syphon, and having a metallic plate in each. This currrent was observed with zinc and sulphuric acid, with zinc sulphate, nitrate, chloride, and acetate, with copper sulphate and nitrate, iron chloride, silver acetate, and nitrate, &c. The electromotive force, however, is but feeble, the largest observed being only ·027 of that of a Daniell — as estimated by Du Bois-Reymond's modification of Poggendorff's compensation method — in a couple, consisting of a solution, containing 30 parts of $Cu SO_4, 5 H_2 O$ in 100 of water, and the same diluted with 29 times its volume of water. In this form of couple the metal is dissolved by the more dilute solution, and deposited from the more concentrated.

Theory of the Telephone.—Professor Challis, in a short article in the *Phil. Mag.* for June, brings his hydrodynamical theory to bear on the action of the telephone. The theory put forward by Professor Challis in 1872, and subsequently supplemented in 1876, conducts to the following general theorems: —"(I.) Assuming that the repulsive and attractive forces of nature are all resultants of modes of pressure of the æther, the actions of such forces on atoms are, in every instance, attributable to *æthereal currents*, whether the atoms be *immediately* acted upon by steady motions of the æther or by æthereal vibrations. (II.) In any instance in which *a gradation of atomic density* exists in the interior of any body, in so far as this condition is persistent, molecular attraction in the direction from rarer to denser parts must be counteracted by atomic repulsion in the contrary direction, and, according to theorem I., these actions are accompanied by ethereal currents." In the telephone an iron diaphragm is set in vibration by the voice, and is supposed to generate electric currents, which by well-known means are made to act on a distant plate, causing it to vibrate, and these vibrations, acting on the contiguous air, reproduce sounds corresponding to the original ones.

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Professor Challis thinks that the hydrodynamical theory of physical forces furnishes an explanation of *why* the means employed should produce such currents; for the component atoms of the plate originally vibrated move to and fro by forces which result from the simultaneous action of atomic repulsion and molecular attraction, varying in direction as the one or the other is in excess. Hence, as these forces are due to harmonic vibrations of the æther, according to the general theor. I., ethereal currents are continually being generated and co-exist with the vibrations of the plate. In order that cognizable effects of these currents may be produced, it is necessary to provide means of circulation, as, in fact, we do in the usual arrangements of the telephone.

Spectrum Produced by the Electric Spark in a Compressed Gas. By A. Cazin.*—It is well known that with a continually increasing pressure the spectrum of a gas gradually alters, its lines steadily widening out, until at length they disappear altogether in a continuous spectrum. This phenomenon is easily explained, if we admit with the author that the illumination produced by the electric spark in a gas is due to solid as well as to gaseous particles; the solid particles which are derived from the electrodes and the walls of the containing vessel become more and more abundant as the pressure increases, their continuous spectrum augments in brilliancy, and they eventually overpower and render invisible the fainter linear spectrum of the gaseous particles. With nitrogen at ordinary pressure, the channelled spaces and lines are at first distinctly visible; with an increase of pressure, the channels gradually fade out, the lines widen, and the continuous spectrum becomes more brilliant. At two atmospheres there are only six lines and five diffuse bands visible. At ten atmospheres only three lines proper to nitrogen can be seen, but the sodium line, which is not distinguishable under ordinary circumstances, has now become very distinct, a tolerably good proof that the sodium is derived from the glass walls of the containing vessel. The spark becomes hazy towards fifteen atmospheres, but the four above-mentioned lines are still visible on the continuous spectrum, together with some brilliant points which are due to platinum. An increase of pressure up to forty atmospheres does not alter the appearance of the preceding spectrum. When the pressure is removed, the spectrum assumes its ordinary aspect, but the sodium line remains persistent, and may even be made to pass from one electrode to the other, as when a sodium compound is electrolysed, by reversing the current. The author has succeeded in photographing these results, and has registered several lines as belonging to nitrogen, which have not been before observed. Under one atmosphere pressure the nitrogen lines in the photograph extend across that portion of the image which is feebly illuminated by a continuous spectrum; upon this back-ground they are defined with exquisite sharpness, as many as thirty being capable of measurement in a space of 3 mm. At eight atmospheres the lines are scarcely visible, but with care, they may still be seen as numerous and as well defined as before. The author proposes to photograph in like manner the complete spectra of all the elementary gases.

The Electrical Resistance of Selenium.—(By L. A. Forssmann*).—In his experiments, the author used bars of fused selenium 2 mm. in diam., the ends of which were softened by heat and welded on to charcoal points in order to ensure a good contact. By long heating in an air bath the bar was made to conduct electricity. A rod thus prepared, and 2·5 cm. in length, was arranged in a wide brass tube with an opening in the side, so that the selenium could be exposed to light or placed in complete darkness. The current was produced by several Meidinger's elements, and the strength observed by means of a galvanometer. It was found, contrary to the results of Siemens and Adams (Pogg. Ann., cl. 333), that the intensity of the current is proportional to the number of elements, so that it obeys Ohm's law; and this was the case whether the selenium was exposed to the action of light or not. The conductivity of selenium is nearly doubled by exposure to diffused daylight, whilst direct sunlight exercises a still more powerful influence. This influence appears to be twofold, one instantaneous, the other gradual, so that the needle only attains its position of equilibrium after some minutes. In daylight, a permanent position of equilibium could rarely be obtained, for a small change in the amount of cloud at once produced a variation in the intensity of the current. The intensity increases in a very slow progression as the distance of the source of light diminishes. The influence of a non-luminous flame is very small, thus confirming the results obtained by Adams. From this it might appear that the luminous part of the spectrum exercises the greatest influence, and that rays of a greater or less refrangibility produce a smaller effect; but it was found that, when the increase in the intensity of the current produced by direct daylight was 43, that by yellow light was 40, by red 39, by blue 34, and by green 18. The increase in conductivity is therefore much smaller when the light has passed through green glass than through glass of any other colour. Consequently, the effect is at a minimum in the green part of the spectrum, and increases on both sides. It was found that light, after passing through various coloured liquids, influenced the conductivity of selenium in a very different degree. A solution of a copper salt, although it transmits a great part of the visible spectrum, diminishes the intensity of the current almost to the same extent as complete darkness. Sulphuric acid, coloured with selenium, which was far less transparent than the copper solution, produced almost as great an increase as direct light, as did also chameleon solution. Nickel salts and indigo solution diminished the intensity of the current, and the latter, when sufficiently concentrated, produced the same results as complete darkness. From the above, the author concludes that the changes in the resistance of selenium are due to vibrations of a different order, if not of a different kind to those which produce light, heat, or chemical activity. The possible influence of longitudinal vibrations must not be overlooked. After a bar of selenium has been exposed some time to light which has passed through the solution of a copper salt the strength of the current rises very quickly above its normal intensity in direct light if the copper solution be removed out of the path of the rays. By using a selenium solution the opposite phenomenon takes place. To explain this we may assume that the vibrations transmitted through cupric chloride tend to produce a new position of equilibrium among the molecules which is strained, and, therefore, unstable; so that when the selenium bar is removed from the solution and the tension ceases a new position of equilibrium is taken up, lying on the opposite side of that produced by direct light, although after some time the normal state is again attained. When the rays from a lamp are transmitted through a selenium solution resistance is smaller than in direct light. This can be explained in one of two ways; either there are rays which produce a diminution of conductivity and are absorbed by the solution, or the passage of the rays through the liquid converts indifferent into active rays—a phenomenon analogous to fluorescence.

* For this abstract we are indebted to the *Chemical Society's Journal*.

ABSOLUTE UNIT OF ELECTRICAL RESISTANCE.

BY PROF. H. A. ROWLAND.

The first determination of the resistance of a wire in absolute measure was made by Kirchhoff, in 1849, in answer to a question propounded by Neumann, in whose theory of electrodynamic induction a constant appeared whose numerical value was unknown until that time. His method, like that of this paper, depended on induction from currents; only one galvanometer was used, and the primary current was measured by allowing only a small proportion of it to pass through the galvanometer by means of the shunt, while all the induced current passed through it. But, owing to the heating of the wires, the shunt ratio cannot be relied upon as constant, and hence the defect of the method. At present this experiment has only historical value, seeing that no exact record was kept of it in a standard resistance. However, we know that the wire was of copper, and the temperature 0° R., and that result obtained gave the reistance of the wire one-seventh smaller than when Weber found for the same wire at 20° R. in 1851.

In 1851, Weber published* experiments by two methods—first, by means of an earth inductor; and second, by observing the damping of a swinging needle. Three experiments gave for the resistance of the circuit $1{,}903 \cdot 10^8$, $1{,}898 \cdot 10^8$, and $1{,}900 \cdot 10^8 \frac{m\,m}{sec.}$ but it is to be noted that a correction of five-eighths per cent. was made on account of the time, two seconds, which it took to turn the earth-inductor, and that no account was taken of the temperature, although the material was copper. He finds for the value of the Jacobi unit, $598 \cdot 10^7 \frac{m\,m}{sec.}$ Three years after that, in 1853, Weber made another determination of the specific resistance of copper.† But these determinations were more to develop the method than for exact measurement, and it was not until 1862‡ that Weber made an exact determination, which he expected to be standard. In this last determination he used a method compounded of his first two methods, by which the constant of the galvanometer was eliminated, and the same method has since been used by Kohlrausch in his experiments of 1870. The results of these experiments were embodied in a determination of the value of the Siemen's unit, and of a standard which was sent by Sir William Thomson. As the old Siemen's units seem to vary among themselves one or two per cent., and as the result from Thomson's coil differs more than one per cent. from that which would be obtained with any known value of the Siemen's unit, we cannot be said to know the exact of these experiments at the present time. Beside which, it was not until the experiments of Dr. Matthiessen on the electric permanence of metals and alloys, that a suitable material could be selected for the standard resistance.

The matter was in this state when a committee was appointed by the British Association in 1861, who, by their experiments which have extended through eight years, have done so much for the absolute system of electrical measurement. But the actual determination of the unit was made in 1863-4. The method used was that of the revolving coil of Sir Wm. Thomson, the principal advantage of which was its simplicity, and the fact that the local variation of the earth's magnetism was entirely eliminated and only entered into the calculation as a small correction. The principle of the method is of extreme beauty, seeing that the same earth's magnetism which causes the needle at the centre of the coil to point in the magnetic meridian also causes the current in the revolving coil which deflects the needle from that meridian. Whenever a conducting body moves in a magnetic field, currents are generated in it in such direction that the total resultant action is such that the lines of force are apparently dragged after the body, as though they met with resistance in passing through it; and so we may regard Thomson's method as a means of measuring the amount of this dragging action.

But, however beautiful and apparently simple the method may appear in theory, yet when we come to the details we find many reasons for not expecting the finest results from it. Nearly all these reasons have been stated by Kohlrausch, and I can do barely more in this direction than review his objections, point out the direction in which each would affect the result, and perhaps in some cases estimate the amount.

In the first place, as the needle also induced currents in the coil, which tended in turn to deflect the needle, the needle must have a very small magnetic moment in order that this term may be small enough to be treated as a correction. For this reason the magnetic needle was a small steel sphere 8 mm. diameter, and not magnetised to saturation. It is evident that in a quiescent magnetic field such a magnet would give the direction of the lines of force as accurately as the large magnets of Gauss and Weber, weighing many pounds. But the magnetic force due to the revolving coil is intermittent, and the needle must show, as it were, the average force, together with the action due to induced magnetization. Whether the magnet shows the average force acting on it or not depends upon the constancy of the magnetic axis, and there seems to be no reason to suppose that this would change in the slightest, though it would have been better to have made the form of the magnet such that it would have been impossible. The induced magnetism of the sphere would not affect the result were it not for the time taken in magnetization. On this account the needle is dragged with the coil, and hence makes the deflection greater than it should be, and the absolute value of the ohm too small by a very small quantity. The currents induced in the suspended parts also acts in the same direction. Neither of these can be estimated, but they are evidently very minute.

The mere fact that this small magnet was attached to a comparatively large mirror which was exposed to air currents could hardly have affected the result, seeing that the disturbances would have been all eliminated except those due to air currents from the revolving coil, and which we are assured did not exist, from the fact that no deflection took place when the coil was revolved with the circuit broken. In revolving the coil in opposite directions very different results were obtained, and the explanation of this has caused considerable discussion. As this is of fundamental importance I shall consider it in detail. The magnet was suspended by a single fibre seven feet long, and the deflection was diminished by its torsion ·00132. No mention is made of the method used for untwisting the fibre, and we see that it would require only 2·11 turns to deflect the needle 1° from the meridian. To estimate the approximate effect of this, we may omit from Maxwell's equation* all the other minor corrections, and we have

$$R = \tfrac{1}{2}\,\frac{G\,K\,w \cos\phi}{\sin\phi + t\,(\phi - \beta)} = \tfrac{1}{2}\,\frac{G\,K\,w}{\tan\phi\,(1+t)}\,\frac{1}{\left(1 - \dfrac{\beta t}{\sin\phi\,(1+t)}\right)}$$

nearly, where we have substituted $\phi - \beta$ for ϕ in Maxwell's equation in the term involving t. In this equation ϕ is measured from the magnetic meridian; but let us take ψ as the angle from the point of equilibrium. Then $\psi' = \phi' + a$ and $\psi'' = \phi'' - a$, where ψ' and ϕ' are for negative rotation, and ψ'' and ϕ'' for positive rotation and $a = \text{arc}\sin\frac{\beta t}{1+t}$.

Let $$C = \frac{2}{G\,K\,w}.$$

Then $$CR' = \frac{1}{\tan\psi'\,(1+t)}.$$

$$CR'' = \frac{1}{\tan\psi''\,(1+t)}.$$

$$R_1 = \tfrac{1}{2}\,(R' + R'').$$

Where R' and R'' are the apparent values of the resistance as calculated from the negative and positive rotations, and R_1 is the mean of the two as taken from the table published by the British Association Committee. If R is the true resistance,

$$CR = \frac{1}{\tan\phi'\,(1+t)\left(1 + \dfrac{\sin a}{\sin\phi'}\right)} = \frac{1}{\tan\phi''(1+t)\left(1 - \dfrac{\sin a}{\sin\phi''}\right)}$$

We shall then find approximately

$$R = \frac{1 + \tan\psi' \tan a}{R'\left(1 + \dfrac{\sin a}{\sin\phi'}\right)\left(1 - \dfrac{\tan a}{\tan\phi''}\right)} = \frac{1 - \tan\psi'' \tan a}{R''\left(1 - \dfrac{\sin a}{\sin\phi''}\right)\left(1 + \dfrac{\sin}{\tan\phi''}\right)}$$

When a is small compared with ψ'' or ψ', and when these are also small, we have

$$R = R_1\,(1 + a^2\,(a^2 - \tfrac{1}{2}\,\psi^2) + \&c.).$$

So that by taking the mean of positive and negative rotations, the effect of torsion is almost entirely eliminated. Now a is the angle by which the needle is deflected from the magnetic meridian by the torsion, and its value is $\frac{1}{2\psi}\left(1 - \frac{R'}{R''}\right)$ nearly, when a is small, and this, in one or two of their experiments, exceeds unity, or a exceeds 28°6 which is absurd. Taking even one of the ordinary cases where $\frac{R'}{R''} = 1{\cdot}02$ and ψ is about $\frac{1}{20}$, we have $a = 12°$ nearly, which is a value so large that it would surely have been noticed. Hence we may conclude that no reasonable amount of torsion in the silk fibre could have produced the difference in the results from positive and negative rotation, as

* Bestimmung der Constanten von welcher die Intensität inducirter elektrischer Ströme abhängt. Pogg. Ann., Bd. 76, S. 412.

† Abh. d. Kön. Ges. d. Wissenschaften zu Göttingen. Bd. 5.

‡ Zur Galvanometrie, Gottingen, 1862.

* "Reports on Electrical Standards," p. 133.

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has been stated by Mr. Fleeming Jenkin in his "Report on the New Unit of Electrical Resistance."*

The greatest value which we can possibly assign to a, which might have remained unnoticed is $\frac{1}{10}$, which would not have affected the experiment to any appreciable extent.

Another source of error which may produce the difference we are discussing is connected with the heavy metal frame of the apparatus, in which currents can be induced by the revolving coil. The coil passes so near the frame work that the currents in it must be quite strong and produce considerable magnetic effect. Kohlrausch has pointed out the existence of these currents, but has failed to consider the theory of them. Now, from the fact that after any number of revolutions, the number of lines of force passing through any part of the apparatus is the same as before, we immediately deduce the fact that, if Ohm's law be correct, the algebraical sum of the currents at every point in the frame is zero, and hence the average magnetic action on the needle zero. But although these currents can have no direct action, they can still act by modifying the current in the coil; for, while the coil is nearing one of the supports the current in the coil is less than the normal amount, and while it is leaving it it is greater; and although the total current in the coil, is the normal amount, yet it acts on the needle at a different angle. By changing the direction of rotation, the effect is nearly, but not quite eliminated. The amount of the effect is evidently dependent upon the velocity of rotation, and increases with it in some unknown proportion, and the residual effect is evidently in the direction of making the action on the needle too small and thus of increasing R. If these currents are the cause of the different values of R obtained with positive and negative rotation, we should find that, if we picked out those experiments in which this difference was the greatest, they should give a larger value of R than the others. Taking the mean of all the results† in which this difference is greater than 1 per cent., we find for the ohm $1{\cdot}0033\frac{\text{earth quad.}}{\text{sec.}}$, and when it is less than 1 per cent. $\cdot 9966\frac{\text{earth quad.}}{\text{sec.}}$, which is in accordance with the theory, the average velocities being $\frac{100}{26}$ and $\frac{100}{43}$ nearly. But the individual observations have too great a probable error for an exact comparison.

But, whatever the cause of the effect we are considering, the following method of correction must apply. The experiments show that R is a function of the velocity of rotation, and hence, by Taylor's theorem, the true resistance R_0 must be:

$$R_0 = R\,(1 + A\,w + B\,w^2 + \&c.)$$

and when R is the mean of results with positive and negative rotations, $R_0 = R\,(1 + B\,w^2 + D\,w^4 + \&c.)$.

Supposing that all the terms can be omitted except the first two, and using the above results for large and small velocities, we find $R_0 = \cdot 9926\frac{\text{earth quad.}}{\text{sec.}}$. But, if we reject the two results in which the difference of positive and negative rotations is over 7 per cent., we find:

$$R_0 = \cdot 9934\ \frac{\text{earth quad.}}{\text{sec.}}$$

The rejection of all the higher powers of w renders the correction uncertain, but it, at least, shows that the ohm is somewhat smaller than it was meant to be, which agrees with my experiments.

It is to be regretted that the details of these experiments have never been published, and so an exact estimate of their value can never be made. Indeed, we have no data for determining the value of the ohm from the experiments of 1863. All we know is that, in the final result, the 1864 experiments had five times the weight of those of 1863, and that the two results differed ·16 per cent., but which was the larger is not stated. Now, the table of results published in the report of the 1864 experiments contains many errors, some of which we can find out by comparison of the columns. The following corrections seem probable in the eleven experiments:—No. 4, second column, read 4·6375 for 4·6275. No. 10, fourth and fifth columns, read 1·0032 and + 0·32 in place of 1·0040 and + 0·40. No. 11, fourth and fifth columns, read 1·0065 and + 0·65 in place of 0·9981 and — 0·19. Whether we make these corrections or not, the mean value is entirely incompatible with the statement with respect to the 1863 experiments. With the corrections the mean value of the 1864 experiments is I. ohm $= 1{\cdot}00071\ \frac{\text{earth quad.}}{\text{sec.}}$, and without them, using the fourth column, it is 1·00014. With the corrections the difference between fast and slow rotation is ·6 per cent. In the year 1870 Professor F. Kohlrausch made a new determination of Siemen's unit in absolute measure, the method being one formed out of a combination of Weber's two methods of the earth inductor and of damping, by which the constant of the galvanometer was eliminated, and is the same as Weber used in his experiments of 1862. His formula for the resistance of the circuit, omitting small corrections, is:

$$w = 32\ \frac{S^2\,T^2\,t_0\,(\lambda - \lambda_0)\,AB}{\pi^2\,K\,(A^2 + B^2)^2}\ \text{approximately.}$$

Where S is the surface of the earth inductor, T is the horizontal intensity of the earth's magnetism, K the moment of inertia of the magnet, t_0 the time of vibration of the magnet, λ the logarithmic decrement, and A and B are the arcs in the method of recoil.

One of the principal criticisms I have to offer with respect to this method is the great number of quantities difficult to observe, which enter the equation as squares, cubes, or even fourth powers. Thus S^2 depends upon the fourth power of the radius of the earth inductor. Now, this earth inductor was wound years before by W. Weber, and the mean radius determined from the length of wire and controlled by measuring the circumference of the layers. Now, the wire was nearly 3·2 mm. diameter with its coating, and the outer and inner radii were 115 mm. and 142 mm. Hence the diameter of the wire occupied two per cent. of the radius of the coil, making it uncertain to what point the radius should be measured. As the coil is wound, each winding sinks into the space between the two wires beneath, except at one spot where it must pass over the tops of the lower wires. The wire must also be wound in a helix. All these facts tend to diminish S, and make its value as deduced from the length of the wire too large; and any kinks or irregularities in the wire tend in the same direction. And these errors must be large in an earth inductor of such dimensions, where the wire is so large, and many layers are piled on each other. If we admit an error of one-half a millimeter in the radius as determined in this way, it would diminish the value of S^2 1·4 per cent., and make Kohlrausch's result only ·6 per cent. greater than the result of the British Association Committee. Three other quantities, T, λ, and K, are very hard to determine with accuracy, and yet T enters as a square. It is to be noted that this earth-inductor is the same as that used by Weber in his experiment of 1862, and which also gave a larger value to the ohm than those of the British Association Committee. Indeed, *the results with this inductor and by this method form the only cases where the absolute resistance of the ohm has been found greater than that from the experiments of* the British Association Committee.

There seems to be a small one-sided error in A and B which Kohlrausch does not mention, but which Weber, in his old experiments of 1851, considered worthy of a ·6 per cent. correction, and which would diminish $\frac{A\,B}{(A^2 + B^2)^2}$ by 1·2 per cent.

This is the error due to loss of time in turning the earth inductor. As Kohlrausch's needle had a longer time of vibration than Weber's, the correction will be much smaller. In Weber's estimate the damping was not taken into account, and, indeed, it is impossible to do so with exactness. To get some idea of the value of the correction, however, we can assume that the current from the earth-inductor is uniform through a time t'', and the complete solution then depends on the elimination of nine quantities from ten complicated equations, and which can only be accomplished approximately.

If γ is the true value of the angular velocity, as given to the needle by the earth-indicator, and γ is the velocity as deduced from the ordinary equation for the method of recoil, I find:

$$\frac{\gamma}{\gamma_1} = 1 + \frac{1}{24}\left(\pi\,\frac{t}{T}\right)^2 \frac{1 - 9\left(\frac{\lambda}{\pi}\right)^2\ (1 + \epsilon^4\lambda)}{(1 + \epsilon^2\lambda)^2} + \&c.,$$

when λ is the logarithmic decrement, ϵ the base of the natural system of logarthms, T the time of vibration of the needle, and t the time during which the uniform current from the earth-inductor flows. In the actual case, the current from the earth-inductor is nearly proportional to $\sin t$, and hence it will be more exact to substitute

$$4\left(\frac{t}{\pi}\right)^2 \int_0^{\frac{1}{2}\pi} t \sin t\, dt = 4\left(\frac{t}{\pi}\right)^2$$

in the place of t^2. The formula then becomes

$$\frac{\gamma}{\gamma'} = 1 + \frac{1}{6}\left(\frac{t}{T}\right)^2 \left(1 - 9\right)\left(\frac{\lambda}{\pi}\right)^2 \frac{1 + \epsilon^4\lambda}{(1 + \epsilon^2\lambda)^2} + \&c.$$

This modification is more exact when λ is small than when it is large; but it is sufficiently exact in all cases to give some idea of

* "Reports on Electrical Standards." London, 1873, p. 191.

† In the table published by the Committee the different columns do not agree, and I have thought it probable that the last two numbers in the next to the last column should read 1·0032 and 1·0065, instead of 1·0040 and ·9981, and in my discussion I have considered them to read thus.

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the magnitude of the error to be feared from this source. Kohlrausch does not state how long it took him to turn his earth-inductor, but, as T = 34 seconds, we shall assume

$$\frac{t}{T} = \frac{1}{10}, \text{ and as } \lambda = \tfrac{1}{4} \text{ nearly, we have } \frac{\gamma}{\gamma'} = 1{\cdot}0008,$$

which would diminish the value of the resistance by ·16 per cent.

As the time we have allowed for turning the earth inductor is probably greater than it actually was, the actual correction will be less than this. The correction for the extra current induced in the inductor and galvanometer, as given by Maxwell's equation, has been shown by Stoletow to be too small to affect the result appreciably.

We may sum up our criticisms of this experiment in a few words. The method is defective, because, although absolute resistance has the dimensions of $\frac{\text{space}}{\text{time}}$ yet in this method the fourth power of space and the square of time enter, besides other quantities which are difficult to determine. The instruments are defective, because the earth-inductor was of such poor proportion and made of such large wire, that its average radius was difficult to determine, and was undoubtedly over estimated.

It seems probable that a paper scale, which expands and contracts with the weather, was used. And, lastly, the results with this inductor and by this method have twice given greater results than anybody else has ever found, and greater than the known values of the mechanical equivalent of heat would indicate.

The latest experiments on resistance have been made by Lorenz, of Copenhagen, by a new method of his own, or, rather, by an application of an experiment of Faraday's. It consists in measuring the difference of potential between the centre and edge of a disc in rapid rotation in a field of known magnetic intensity.

A lengthy criticism of this experiment is not needed, seeing that it was made more to illustrate the method than to give a new value to the ohm. The quantity primarily determined by the experiment was the absolute resistance of mercury, and the ohm will have various values according to the different values which we assume for the resistance of mercury in ohms. One of the principal defects of the experiment is the large ratio between the radius of the revolving disc and the coil in which it revolved. In conclusion, I give the following table of results, reduced as nearly as possible to the absolute value of the ohm in $\frac{\text{earth quad.}}{\text{sec.}}$

Date.	Observer.	Value of Ohm.	Remarks.
1849	Kirchhoff	·88 to ·90	Approximately.
1851	Weber............	·95 to ·97	„ „
1862	Weber............	1·088	From Thomson's unit.
		1·075	From Weber's value of Siemen's unit.
1863-4	B.A. Committee	1·0066	Mean of all results.
		·993	Corrected to a zero velocity of coil.
1870	Kohlrausch ...	1·0196	
1873	Lorenz	·970	Taking ratio of quicksilver unit to Ohm = ·962.
		·980	Taking ratio of quicksilver unit to Ohm = ·953.
1876	Rowland	·9912	From a preliminary comparison with the B.A. unit.

[TO BE CONTINUED.]

THE MICROPHONE.*

The following experiments were suggested by the description, which appeared in a recent number of *Nature*, of the microphone lately invented by Professor Hughes. Instead of the pointed piece of carbon supported between two pieces of the same material as used by him, it occurred to me that ordinary gas cinders would be likely to answer the purpose tolerably well. To test this, I included in the circuit of an ordinary Bell telephone, a single Leclanché cell, and a small jelly can half filled with cinders broken into pretty coarse fragments. The connections were made by slipping down at opposite sides, between the cinders and the sides of the jar, two strips of tin, to which the circuit wires were attached. When the simple instrument was used as a transmitter, articulate sounds were heard very loud and distinct in the distant telephone, though occasionally marred by what appeared to be the rattling of the cinders in the jar. With this transmitter sounds were also quite audible, even when the speaker stood several yards away from it.

I next took a shallow box, made of thin wood, about fifteen inches by nine inches, and filled it with cinders, taking care, in the first place, to nail to the inside of its ends two pieces of tin to which wires could be attached. Having nailed down the thin lid of the box, and included it in the circuit of the telephone, along with one Leclanché cell, I found that it made both a very sensitive microphone, as well as an excellent transmitter for the ordinary telephone. With three of these boxes hung up like pictures on the walls of a room, and connected in circuit, almost any kind of noise made in any part of the room was revealed in the telephone. Speaking was heard distinctly, and a part-song by two voices in the middle of the floor was rendered with surprising clearness and accuracy.

In my next experiment, still using the same cell in the circuit of the telephone, I tried as transmitter a single elongated cinder with the wires wound tightly round each end. Sounds uttered close to this cinder were quite audible, but I failed to hear them when I substituted for the cinder the carbon of a Bunsen cell with brass clamps firmly attached to each end, into which the circuit wires were screwed. Possibly either the more porous and friable nature of the cinder or the comparative looseness of the wire attachments, may have had something to do with this difference of effect.

I next removed the Leclanché cell from the circuit and used as transmitter the jelly can containing dry cinders. I sometimes fancied that I heard sounds even with the cinders dry, but they became faintly, though distinctly, audible when the cinders became slightly moistened by the breath of the speaker. However, on pouring water into the jar, so as almost to cover the cinders, the sound was heard on the telephone almost as well as when the Leclanché cell was in circuit. I did not, however, hear any sound with the cinders removed and water only in the jar, not even when the conducting power of the water was increased by being slightly acidulated.

In my next experiment I tried if the jar with the cinders would act as a receiver as well as transmitter, and was not a little surprised to find that it did so. For this purpose I used similar jelly cans, containing cinders both for transmitter and receiver, and included a battery of two Grove's cells in the circuit. Articulate sounds uttered in the one cinder jar were distinctly heard in the other, and even voices could be distinguished. However, the results were not so good as I have no doubt they will yet be, when better forms both of transmitter and receiver are adopted. Here we have the beginning of a kind of telephone worked entirely by the electric current without the aid of magnetism. I also tried successfully an ordinary telephone as transmitter and a cinder jar as receiver, but in this case the sounds were somewhat fainter and not so easily distinguished. I remarked, also, that when an intermittent current was sent through the cinder jar a very distinct rattling noise issued from it.

In order to find out if the cinders in the receiving jar were at all jostled about when sounds were being transmitted to it from a similar jar, the following experiment was tried. A strong battery was included in the circuit, and a clean glass jar containing cinders taken as receiving instrument. When this was taken into a dark room small flashes of electric light were observed here and there amongst the cinders while sounds were being sent.

* Abstract of a paper read before the Royal Society of Edinburgh on June 3, 1878, by James Blyth, M.A., F.R.S.E.

TELEPHONE IMPROVEMENTS.

Professors Houston and Thomson have developed an apparatus which combines in its action certain principles not heretofore used. They thus obtain an increase in the volume and an improvement in the quality of the sound. The iron diaphragm supports at its centre a small point of plumbago. This point dips into a mercury globule placed in a suitable cavity in the end of the iron core nearest the diaphragm. The iron core has on it a primary coil, which forms part of a battery circuit, in which come the variable resistances—the plumbago point and the mercury globule. On speaking, the vibration of the diaphragm causes the point to dip more or less into the mercury, and thus to increase or decrease the resistance of the circuit. By this means, an increase of the primary current occurs when the point makes better contact, producing an increase of magnetism in the iron core, causing a still further approach of the diaphragm and increase of current, till the elasticity of the diaphragm equilibriates the attraction of the magnet. When the diaphragm recedes, opposite effects are produced. The changes thus produced give rise to inductive currents in the secondary coil, which pass into the line and the receiving instruments. It is evident that any variation in the primary current consequent on the motion of the diaphragm *reacts* to increase such variations; while the induced current in the secondary still further reacts to increase the effects. Hence the instrument has been called the *reaction telephone*.

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DISPUTED INVENTION OF THE MICROPHONE.

However carefully we may discriminate between the claims of rival inventors, some one is sure to be dissatisfied. It is seldom that a couplet of names gets firmly fixed and commonly used in the discussion of any single discovery. Adams and Leverrier is a couplet, however, almost universally adopted in relation to planetary discovery; and Janssen and Lockyer have, it is said, coequal claims to the discovery that certain sun prominences can be observed under ordinary conditions and without the intervention of an eclipse. Claims have at times been put forward by electrical discoverers, but we do not remember any couplet of names generally in use. It seems, however, that at the present time we shall have to discuss the claims of more than one discoverer in the direction of the microphone.

Professor Graham Bell, Mr. Elisha Gray, Reiss, and others studying the connection between acoustics and electricity, made some wonderful discoveries. A new mania, which may aptly be termed telephonia, spread with electrical rapidity throughout the world. Hundreds of able investigators turned their minds to the study of the new discoveries; modifications and improvements succeeded each other so quickly that one found it almost impossible to keep pace with what was being done. Then to us in England came the sudden announcement, through a paragraph in *The Times*, that a greater discovery had been made. Soon Mr. W. H. Preece followed this up with a reference to it at the meeting of the Society of Arts, and Professor Hughes gave a detailed statement of his work to the Royal Society. "The Microphone" was a heading found in every paper, and was discussed everywhere. Amateurs and grey-headed savants hastened to explore the new region, and a wonderful harvest is being garnered. Professor Hughes has the priority of publication, and we do not doubt that Professor Hughes has worked out his discovery independently of all external information. So far as we can judge, the honour due to him is the greatest we can give, and, did our words carry any influence, we should say that the Royal Society ought to elect him a member and give him their most valued medal. We admire the inductive reasoning that led Prof. Hughes to continue his experiments, but we must admit that other workers deserve our consideration, inasmuch as they have, also working independently, achieved the same or similar results. Wentworth Lascelles Scott, we have every reason to believe, from documentary evidence, had in England obtained such results early during the present year. His work, however, was not made public except to friends, and thus, as we have previously said, Prof. Hughes claims priority of publication. A contemporary has more than hinted that Mr. Scott's work is apocryphal, but the evidence, we hold, is too strong for such belief to be entertained for a moment. It is noticeable, however, that our contemporary was writing under the influence of great annoyance, inasmuch as its attack is not so much directed against Mr. Scott as against *The Engineer*, which published an account of Mr. Scott's work. We do not at the present time intend to dwell upon Mr. Scott's claims. We feel that he must be satisfied with an acknowledgment that his work was independent. This article is principally written for another purpose. Mr. Edison makes a serious charge against Mr. W. H. Preece, and, as the charge is so grave, we cannot do better than give it in the words of the *New York Herald* for the 4th of June:—"Brain Stealing.—A most regrettable attempt to steal from Mr. Edison the honour of having invented the thermopile is being made in England, where, owing to the inventor's too free explanation of his plan, a knowledge of his secret was obtained. The fact that Mr. Edison trusted to the honour of a party who came out to investigate his inventions, and to whom he confided the particulars of this one, has enabled one of those scientists who could have shown Columbus how to stand an egg on end, after he had seen the great Captain do it, to come before the world claiming an invention on which Edison had been working successfully for a year or more. In this case Mr. Edison has suffered from what many great inventors before him have experienced—namely, the base attempts of so-called scientists to win honour and profit from the work of other men's brains." Mr. Edison is stated to say:—"I discovered about two years ago that carbon of various forms, such as plumbago, graphite, gas retort carbon, and lampblack, when moulded in buttons, decreased the resistance to the passage of the electrical current by pressure. This is part of the apparatus of the carbon telephone and microphone. The Washington *Star*, on April 19, published this discovery, and I sent twenty copies of the paper to foreign countries, one of them to Mr. W. H. Preece, Chief of the Postal Telegraph Department in London. I have corresponded with Mr. Preece and kept him posted. Professor D. E. Hughes, of England, now claims to have invented the telephone, microphone, and thermopile. At that time Mr. Preece had in his possession telephones exactly similar to that which Mr. Hughes sets forth as his. Mr. Preece was also present in this country, where I showed him the increase and decrease of pressure by the thermopile. In June, 1877, an account of my discovery appeared in the *Journal of Telegraphy*." Mr. Edison has sent the following cable despatches concerning the matter to London:—"Preece, London: I regard Hughes's heat measure and direct impact telephone as an abuse of confidence. I sent you and others papers describing it, also in letters about trouble with expansion telephones. If you do not set it right I shall, with details.—Edison." "Sir William Thomson, Academy of Sciences, London: Carbon telephones sent Preece two months ago; also publications and letters describing it as heat measure. Great abuse confidence his

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part in Hughes matter. Await publications with proofs. Edison." Now, it may turn out that Mr. Edison's discovery is quite different to that of Professor Hughes; at any rate, we are quite sure that Professor Hughes is far too honourable to lay claim to any other person's work. He could scarcely have known of Mr. Edison's discoveries, and has independently worked in the same direction.

It is extremely painful to discuss matters of this kind; not only is the honour of Mr. Preece at stake, but it must be remembered that Mr. Preece was sent to America as the representative of England; so, in this case, a disclaimer will be of more than private importance. There must surely be some great mistake somewhere. So far as we know, Mr. Preece has never hinted at such a discovery of Mr. Edison's, and the proof of his knowledge of it must be great before we can allow such aspersions to take root among us. Mr. Preece has, by his own statements, not only been fully cognisant for some time past of the work of Professor Hughes, but has been the principal instrument in bringing the discovery before the public, and, if he really knew that Edison had previously discovered the same thing, it seems strange that he should have allowed so much valuable time to be wasted, or the discovery to be brought before the world as original.

ON THE STUDY OF ELECTRICITY AS A PROFESSIONAL PURSUIT.

BY THOMAS T. P. BRUCE WARREN.

III.

I have often thought that a collection of the various forms of batteries which have been used would possess many features of usefulness, apart from its high importance as a scientific curiosity. As it would not be convenient to keep such cells in a working condition in a museum, it would be better to have good models, so that a student could handle or inspect them. The number of voltaic combinations and arrangements which have received a practical application is of necessity very small.

The various devices which have been employed in studying the action of different combinations, and which have resulted in the present forms of batteries, are surely worth laying before the electrical student, and should be incorporated in future text-books. A chapter devoted to considerations of this kind would increase the desire to obtain a little chemical knowledge.

The amount of chemical knowledge which the electrician ought fairly to possess is not necessarily very extensive; however, the more the better, and, if a chemical laboratory be attached to a foreign station, it would afford a source of amusement and instruction. Every electrician ought to know how to test his battery materials. Sulphate of copper may contain iron, magnesia, zinc, &c., either as adulterants or accidental impurities. Sulphate of soda may be used to adulterate sulphate of zinc as well as sulphate of magnesia. Spelter contains, iron, lead, arsenic, silica, sulphur, sometimes copper, cadmium, and fluorine. Binoxide of manganese is liable to great variation. Sulphuric acid, although apparently correct from its specific gravity, may be largely diluted with water and solutions of cheap sulphates added to conceal the fraud. I would strongly advise anyone studying electricity as a profession to be satisfied with nothing short of such a knowledge of the chemistry of the materials which he uses that he can perform a neat quantitative analysis. Two works on electricity now before me give the following means of testing sulphate of copper. Add ammonia to the solution, which will first precipitate the iron and copper together, which on further addition of ammonia will leave the iron undissolved. I will simply point out that ammonia dissolves other oxides besides copper,

There are many points of commercial consideration involved in batteries, which will be dwelt on in a future paper. I propose to deal here more especially with the forms of battery used for testing, and to commence with those modifications of the Daniell's cell which are of most importance.

Faults in Batteries.—Culley and Jenkin give the following as some of the faults which may be met with in batteries:—Dry cells, corroded terminals, contact between the elements in a cell, and loose or broken connections, inconstant currents from bubbles of gas suddenly detaching themselves from the plates. If a battery is perfectly seen to, a dry cell or imperfect replenishing should not be possible. Coroded terminals are avoided by having the connections, all soldered and well smeared over with a little marine glue whilst warm. Every connection exposed to the action of the liquids, or the efflorescent salts, from a battery, should be well varnished or smeared with marine glue. Contact between the elements in a cell may be produced by the deposition of copper from the sulphate on the zinc, which, unless its growth is arrested, extends down to the copper plate. Sometimes the copper plate may be jerked up and touch the zinc, or the wire leading up from the copper may touch the zinc; the latter is avoided by using insulated wire for batteries. Loose connections may result from shaking or corrosion; broken connections more frequently happen from parts being eaten away by the liquids; the junction of the copper discs with the wire leading from them, unless protected, leads to this kind of fault. Inconstant currents from bubbles of gas are due to the accumulation of air or hydroden on the zincs which are given off when the battery is shaken, or put in action. These are faults which, for testing purposes, put an end to the use of the battery. There are other faults which, although they do not produce any serious impediments to the use of a battery, will generally result in a break-down when, perhaps, the battery may be urgently required.

Changes of temperature will alter the condition of a battery slightly. If warm water be used to dissolve the salts for exciting fluids, care should be taken that everything is cooled to the ordinary temperature before using the cells. Evaporation from a cell produces a damp atmosphere in the battery room, and, if the solutions are tolerably saturated, a creeping over the edges of the cells takes place, which gradually leads to crystals being formed; these, by capillary attraction, draw up more liquid, so that a copious growth is produced, and the fluid trickles down the outside of a jar or cell. Bubbling from great action going on in a cell will produce the same result. Evaporation is prevented by sealing the cells over, by a few drops of oil, or, preferably, liquid petroleum, of high density and boiling point, being dropped into the cells. This plan, however, is not recommended, as the surfaces of the plates being soiled with oil prevent the battery solution acting. Coating the surface of the cells with melted paraffin will, to a very great extent, prevent "creeping." Its repellent action to wetting keeps off the deposition of moisture. If moisture does deposit, it tends to collect in minute drops.

India-rubber covered wire is the best for battery purposes, especially where melted paraffin is used for sealing up the cells. Its surface should be free from felt or other porous material. Gutta-percha may be used safely if the core is passed through a perforated cork previously well boiled in paraffin wax. The hot paraffin does not then soften the gutta-percha so as to injure it.

In putting up a battery, care should be taken to remove all the air from the cells and materials. Air bubbles find their way into a battery from the water or the crystals used.

If a cell is imperfectly supplied with sulphate of copper, or the decomposition takes place too fast, an accumulation of hydrogen on the under surface of the zinc takes place. Hydrogen will also be readily attracted to the copper disc where any finger stains are left; a bright, clean surface must be given to the plates. To prevent the accumulation of hydrogen on the zinc, a good plan is to place over the copper a layer of some porous substance, as sawdust or broken pumice well saturated with solution of sulphate of copper; the hydrogen bubbles escaping through the liquid are arrested, and the sawdust in time becomes covered with reduced copper. A disc of fine muslin or cotton cloth answers the same purpose, though not for so long a time. I have sometimes, though not often, seen the copper disc or ribbon very much eaten away, as though by local action. This I have noticed takes place when a cell has been imperfectly supplied with blue stone; the copper tarnishes, and the action of the cell appears inverted, especially if the zinc has become covered with the mud-like deposit of copper. A bit of solder dropped on to the copper-plate, or a small fragment of zinc, has been known to lead to the oxidation and partial disappearance of the copper,

To detect these faults in a battery.—A dry cell, or one in which the liquid is below under surface of the zinc, or a broken connection, may be found by the ordinary test for continuity. To facilitate the making of this test without taking the battery to pieces, it is worth while soldering the coppers and zincs together to leave a length of wire standing up, as shown in figure No. 1, so that a terminal may be screwed on without unsoldering any of the permenent connections. The whole battery is joined up to an ordinary detector through a resistance to avoid passing a strong current through it; no deflection being obtained, the plug in the battery-board is moved to the next hole, the test repeated, and so on, until the plug being placed in a hole, a deflection is obtained. A wire is then led to the battery room and the section of the battery between the last two portions tested; it is examined by screwing it on to the wire

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projection. This wire is connected to the detector instead of a wire from the "board." In this way such a fault is detected and remedied without unsoldering the connections.

A partial or intermittent contact may be found by joining up a number of condensers or a good length of insulated wire. The connections are made on a reflecting galvanometer as for "insulation test." The whole battery plugged on gives a shaky or unsteady deflection. The plug is moved in the battery board as before until a steady deflection shows the section containing the fault, the loose connecting wire is employed as before until the faulty cell is discovered. If the fault is caused by contact which is obstinate, and the shelves are very rigid, it may be necessary to get some strong person to bump up against the shelves so as to jerk the contact away.

A battery gives a very low electromotive force, either from contact across the cells, as a copper and zinc in contact, or a very bad cell, containing no solution and acting in the "inverted way." The quickest way is to work out this fault by discharge tests. As before, in shifting the contacts a point will be found where the nominal number of cells agrees with the deflection obtained; the other point, by giving a deflection corresponding to a few cells less than the nominal number, indicates the faulty section. If the fault is very large, an insulation test may be used, but if the fault is small the electrification given to a core may so influence the insulation readings that the effects due to a few cells more or less cannot be detected. An electrometer may be used if the range of battery power to be tested is not too great. If so, the easiest way is to test every ten or twenty cells. Whenever a battery is fitted up for testing or scientific work it saves time and trouble to test it in this way before using it. A set of 10 cells may be joined up to its next set in the wrong way, or one cell in a set itself may be so turned about. The liquid poured in

FIG. 1.

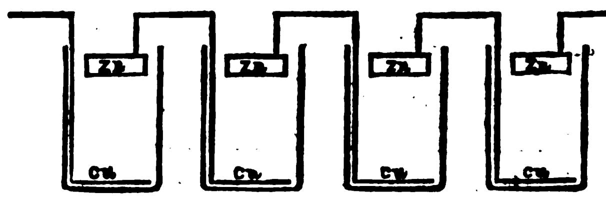
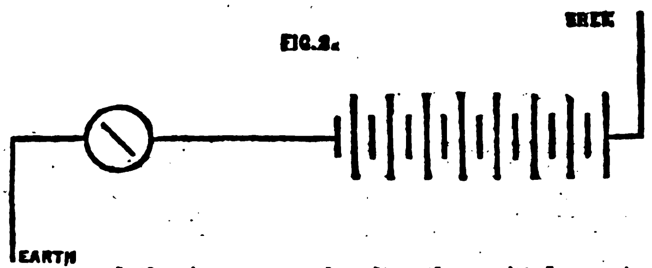


FIG. 2.



may not reach the zinc, or may be altogether omitted, a contact may be left not soldered, or a connecting wire may be broken. The battery, as a whole, should well insulated, and each cell separately well insulated from those adjacent to it. If a battery leak heavily, which is due to some particular portion not being insulated—a cracked cell losing its contents which is dripping over the framework of the shelves, for instance—the position of such a fault may be found by joining the battery to a galvanometer as shewn below, (see Fig. 2.) One end of the battery being insulated, the circuit is completed through the galvanometer, which has one of its terminals connected to earth. The battery is for this test disconnected at convenient places into separate parts, for which purpose it is desirable to have the cells joined up with soldered connections, say into twenties, which are connected to make up the whole battery by means of good binding screws.

Ebonite is the best material for standing batteries on; it is easily washed, is not acted on by the air or the substances employed to any serious extent, nor affected by dampness. It is also a very superior insulator.

Ebonite cup insulators form very good supports for a battery, and, as the weight of a large battery may be more than the ebonite sheet will stand, it is better, perhaps, to have a stout board, and to insert the insulators as legs. In this case, if an ebonite sheet ¼" thick be used on the board, most perfect insulation may be obtained.

Evaporation from a battery will alone give a good degree of leakage; hence the necessity of sealing up the surfaces as much as possible, and employing glass with fair insulating properties.

To test the battery board and wires leading from the cells to it, unscrew all the wires from the board, and proceed as in Fig. No. 2, screwing on one wire at a time to the board, and testing as before, until all the wires are joined into their places.

It is never desirable to leave a large number of cells joined up unless they are wanted, but to leave them in sets of 100 or 250 by removing the binding screws when they are done with.

A large battery, say of 1,200 cells, if properly put up and handled carefully with proper attention, need never be that source of trouble and expense which a few years ago rendered the maintenance of such a battery for testing a most difficult task.

[TO BE CONTINUED.]

CORRESPONDENCE.

ERRORS IN TELEGRAPHY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I venture to send the following remarks on Sir James Anderson's recent articles in your paper on telegraph-ciphers. As a very large part of our firm's telegraphing is on account of constituents, and is paid for by them, we are in a position to take, to some extent, a disinterested view of the question, and our feeling is that there is no antagonism between the freest facilities to telegram-senders and the real interests of the telegraph companies in this matter.

1. *Ten-letter limit.*—Is not Sir James somewhat hard on merchants in the Eastern trade, when he complains that they take full advantage of the 10-letter limit? So far as telegrams to and from India are concerned the St. Petersburg Rules made the following restrictions on previous facilities. Before they came into force we had:—

5-letter groups giving	11,881,376	ciphers
5 figure groups giving	111,111	„
Words of not more than 7 syllables, but confined to Dictionaries and Gazetteers only, about	250,000	„
In all	12,242,487	„

The St. Petersburg rules deprived us of the five-letter groups. By making compulsory the repetition of the figure groups they practically, also, deprived us of them. The seven-syllable rule was altered to ten letters, and this, in the verbs of the inflexional languages alone, made a difference of 50,000. Altogether the available ciphers from dictionaries and gazetteers of the languages in the States who signed the Convention, and in Latin, are now about 125,000—that is to say, we have now about 120,000 ciphers (if dictionaries and gazetteers alone are to be reckoned) to choose from, instead of 12,242,487 as before. Were all these restrictions accompanied with a reduction in the tariff? No. Now we are charged 4*s*. 6*d*. a word to India, instead of 4*s*. as before. The ten-letter rule put all of us in the Eastern trade to immense inconvenience when it took effect, and I do think Sir James should give us the credit we all deserve for adapting ourselves to it instead of complaining that we take full advantage of it. Surely a prisoner is entitled to the full length of his chain, without being warned that it will be shortened still further if he makes the most of it.

Further, European merchants are allowed fifteen letters, and in messages to the United States the old rule of seven syllables still holds good. The West has the benefit of such words for a single tariff as "incomprehensibleness," or "Versicherungsgesellschaft;" but the East is limited to such words as "comprehend," and this notwithstanding that the trade of the East is the far more important and complicated one.

But, in one respect, the St. Petersburg Convention did make an enlargement of the previous practice. Instead of "words in dictionaries and gazetteers," it simply states that "combinations of words contrary to the usage of the language are not admitted." This clearly admits legitimate word-combinations, whether they are in actual use or not, such, for instance, as the fictitious names in literature or otherwise formed in accordance with the principles of the language to which they belong. It is on this view of the rule that the careful work of Mr. Whitelaw, giving 100,000 ciphers, on which Sir James comments, is framed. There are all sorts of wrongly got up schemes now in force for giving a large quantity of ciphers in a small space, and words from them are regularly passed through the ignorance of the telegraph clerks. Many of these schemes have come before me, but I have always refused to use them. Mr. Whitelaw's work, however, commended itself to our own, and many other of the large East India firms, in that it rests on an undoubted philological principle, and is perfectly defensible. What, then, can be thought of the telegraph companies, who daily pass spuriously made up words, and now attempt to put down a genuine work? I believe Mr. Whitelaw's work effects the purpose for which it is intended, in the only legitimate way in which it can be done in the same space.

The St. Petersburg convention, then, by this rule of "word-

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combinations not contrary to usage," does give a facility by which a large number of ciphers can be put into a small space. In this way the inconvenience of large masses of consecutive words is avoided, and the errors that occur in the transmission of messages are readily discovered.

Now, the English postal telegraph authorities, in framing their rules from the St. Petersburg Convention, carried on the previous restriction of "Words in Dictionaries or Gazetteers," instead of the new rule of "Word Combinations not contrary to usage," and, on this particular, there is a strong feeling that they have not taken care of the facilities and convenience of the public as they should have done.

When the next Telegraph Conference takes place, therefore, it will be for the merchants in the Eastern trade either to resist any alteration in the present St. Petersburg rules, as it would put them all again to much expense and inconvenience, and to see that the rule as to "word-combinations" is interpreted to mean *all* legitimate word combinations; or, on the other hand, if the words are to be restricted to "Dictionaries and Gazetteers," to endeavour to have the 7-syllable rule restored, as now in force for America.

2. *Length of Whitelaw's Words.*—Sir James says they are, *generally speaking, for all words the maximum number of letters.* In fact, of the 100,000 words no fewer than 49,693 are of nine letters and under, so that only about half reach the maximum.

3. *Accuracy of Whitelaw's Words.*—Sir James wound up his first article by a promise to show that Mr. Whitelaw's words would not tend to accuracy. He wrote previously, "I think it can be demonstrated that Mr. Whitelaw's word-combinations make accuracy improbable." His second article is the strongest commendation of Mr. Whitelaw's system that could have been given. He makes no complaint against any of Mr. Whitelaw's prefixes. Of his 300 affixes he selects fourteen, which he says are too like other fourteen. They will not likely go into any of the other fourteen, but they may go into something which will render it doubtful which of two words the mangled word is. That is all he can say against the system, and to obtain even this he is obliged to imagine such far-fetched and improbable conversions as "e," a dot, into "o," three bars, a "d" into an "s," an "s" into a "d," and so on. Every one who has had any experience in receiving code messages knows that, if a mangled word must be one of two, it can, in 99 cases out of 100, be readily deciphered from the context. Of course, in the first edition of any work, perfection cannot be obtained, but Sir James's criticism has shown that Mr. Whitelaw's code as regards accuracy is as near perfection as possible. Now, one fact being worth a hundred opinions, since our firm and its correspondents commenced to use this work in July last year they have had no occasion to ask for repetitions. This experience extends to about 800 messages, and others who have used this code have found it work equally well. Words, of course, have been mangled, but have been readily deciphered, as they are all in such small space. For instance, the other day "Golambagh" was telegraphed "Mozambagh." Had such an error occurred in any other code, a repetition would have been necessary. But by Whitelaw's code the right reading was discovered in a few minutes.

4. *Authorised Code of* 50,000 *Words.*—Sir James suggests this. Now, I have had great experience in compiling these vast masses of words, and the difficulty has been with mangled words to trace them among such a large number. For instance, if such an error as that referred to in the last paragraph had occurred, where could we have looked for it? This is just the crowning merit of Whitelaw's system, that it is in such small compass, and mangled words therefore so easily discovered. Besides, the whole mercantile community will refuse to be restricted in its use of legitimate ciphers to any number. Sir James writes that 50,000 words should be sufficient, and if more are wanted they should be paid for. But this is not the right way to look at the subject. For a business that deals in one article, or that has one branch, 1,000 ciphers may suffice, but when, as in many trades, more than 1,000 different articles and descriptions have to be telegraphed about, or where one business has several branches, as ships, produce, piece goods, &c., more than 100,000 ciphers may be needed. *And they are paid for in the extra telegraphing necessary,* not by an enhanced rate, as Sir James would propose.

5. *Effect of a High Tariff and Free Selection of Code-Words.*—Codes and code-words are mainly of service for market quotations and business of a regular character. For urgent business and complications daily arising they are, at their best, sometimes no help at all—often only a partial help; so that for this class of business the telegraph companies obtain all the benefit of their high tariff. On the other hand, codes give both merchants and the telegraph companies the benefit of a low tariff for all classes of business information which a high tariff would stop. Hundreds of instances in our own experience can be given where the more we completed and perfected our codes the more telegraphing took place, and this can only be done by the command of a large number of ciphers. Restriction of ciphers means really a high tariff and reduced telegraphing—that is, telegraphing only in cases of absolutely necessity; whereas, it is clearly the interest of the companies to encourage the freest use of the wires for all kinds of business and information; so that really a high tariff, combined with a free selection of code-words, gives the companies the benefit both of a high and of a low tariff.

Another way by which merchants can obtain the benefit of a low tariff is by joining together to bear the cost of a message with information of common interest. Restrictions on ciphers are sure to encourage this to some extent.

What, therefore, seems best for all parties is this:—Do not disturb and worry the public again, but stick to the present St. Petersburg Rules, ~~properly interpreted,~~ and the 10-letter limit (the latter is the very lowest maximum that would have been at all endurable, but we ~~have all now become~~ accustomed to it); do everything to encourage the free use of all *legitimate* ciphers within the 10-letter limit, and do not put down such genuine and useful works as that of Whitelaw, which really tend to increased telegraphing; fix your tariff according to your experience of the St. Petersburg Rules. The telegraph lines to the East are most admirably worked, and no one grudges that they should be remunerative to their enterprising promotors and shareholders.

14th June, 1878. ANGLO-INDIAN.

THE MICROPHONIC PROBLEM.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Under the above heading there appeared in your issue of Saturday last a somewhat remarkable paper—a paper remarkable as containing one of the most curious "theories" that have yet been propounded to explain the action of the microphone. The theory in question ascribes the wonderful effects of Professor Hughes's instrument to some peculiar, and so far as the author of the paper is concerned, unexplained action of combustion. No experiments in support of this theory being adduced, one is led to the conclusion that it has been evolved solely from the author's inner consciousness. The author, with a most becoming modesty, and with an evident desire to accord to all discoverers the credit due to them says:—"Combustion, Professor Bell thinks, has something to do with the operation." This statement is founded, doubtless, upon an observation made by Professor Bell in the course of the discussion which followed the the reading of Mr. Preece's paper on the microphone, at the Society of Telegraph Engineers. If my memory serves me well, Professor Bell said that in the course of his telephonic experiments with a vibrating reed he had observed a peculiar spark. I leave your readers to judge whether by this Professor Bell meant to imply that combustion had a share in the action of the microphone. Judging from the following statement in Mr. Laister's paper, I am led to the conclusion that he does not clearly understand the meaning of the term combustion:—"Unquestionably combustion does take place when two ends of a voltaic circle are linked by a piece of carbon. . . . . The spark itself is, *of course,* a mere indication of the combustion going on." Would Mr. Laister be surprised to hear that the spark is no indication of combustion; and that when two ends of a voltaic circle *(sic)* are linked by a piece of carbon, combustion does not necessarily ensue. For Mr. Laister's information I may, perhaps, be allowed to explain that the term "combustion" implies chemical action, and that combustion can only go on in the presence of two or more substances capable of acting upon one another chemically. If a tube, containing pure and attenuated nitrogen gas, and having electrodes of pure platinum fused into its ends be included in the secondary circuit of a sufficiently powerful induction coil, and the tube be examined by the spectroscope, there will be obtained the bright line spectra of nitrogen and platinum, proving that these substances exist in the tube in the form of incandescent gas; and yet there is no combustion. Why? Because nitrogen and platinum are not capable of uniting chemically. Again—it is well known that if a powerful galvanic battery be furnished with carbon poles, and if the circuit having been completed the poles are slightly separated, the electric arc is obtained. If this takes place in air, combustion will, to a certain extent, go on; but it is simply because the carbon and the oxygen of the air are capable of entering into chemical combination at the temperature of the arc. If the arc be formed in (say) a nitrogen vacuum, combustion is not possible; but, nevertheless, the carbon points become incandescent emitting light and heat. If Mr. Laister will grant this, he must, I think, also acknowledge that the mere presence of a spark at the surfaces of contact of the microphone carbons does not prove combustion. That the phenomena are *not* due to combustion is incidentally shown in the most cor-

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clusive manner possible by certain experiments recently performed in the laboratory of this institution by Mr. J. Probert. I will not do more than merely allude to these experiments, as they will probably be shortly communicated to you by Mr. Probert himself. In conclusion, I may refer Mr. Laister to Professor Hughes's statement that in the construction of his earlier microphones, his great difficulty was to obtain a substance that did not oxidize (*i.e.*, undergo combustion), and that some of his best microphones are now constructed of solid gold, a substance which, in common with mercury, platinum, and the other so called noble metals, is extremely slow in oxidation.—I am, &c.,

Birkbeck Institution, ALFRED W. SOWARD.
June 17, 1878.

STUDENTS' COLUMN.

NOTES ON STATIC ELECTRICITY.

BY O. LODGE, D.SC.

[CONCLUDED.]

If s be the capacity of one of the insulated plates of a condenser in space by itself, and S its capacity when brought near an earth-plate, the ratio $\frac{S}{s}$ is called the "condensing power."

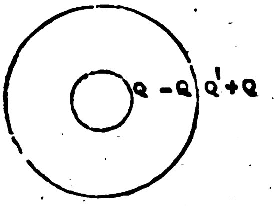
For spherical conductors it equals $\frac{R'}{R'-R}$. To find the attraction of two discs for each other, if the lines of force between them are parallel, let A be a trap door and consider the attraction of the lower plate on it when it is electrified to density ρ and potential V, and the lower plate is earth-connected, and has density.

As in last problem, $V = 4\pi\rho t$, and the force at A being $2\pi\rho$ on each unit charge, the whole force is $2\pi\rho A\rho$, or $F = 2\pi\rho^2 A$. Hence $F = 2\pi A\left(\frac{V}{4\pi t}\right)^2$

If F is measured, the potential V is determined in terms of it, $V = t\sqrt{\frac{8\pi E}{A}}$ So, by measuring F in degrees, we obtain an absolute electrometer.

Specific Inductive Capacity (K.)—It is found that the capacity of a condenser depends not only on its dimensions, but also on the nature of the dielectric medium between the plates. The

FIG. 1A.



ratio between the capacity of a condenser with some medium between the plates to the capacity of the same condenser with air between is called the "specific inductive capacity" of that medium. Thus, the capacity of a glass Leyden jar is:

$\frac{KA}{4\pi t}$ or $\frac{A}{4\pi\frac{t}{k}}$, and K is about 1·8 for glass. The quantity $\frac{t}{k}$ is sometimes called the "reduced thickness." If the dielectric is partly air and partly something else—say a plate of shellac θ cm thick, and the rest $t - \theta$ cm of air—the capacity is then:

$$\frac{A}{4\pi\left(t - \theta + \frac{\theta}{k}\right)}$$

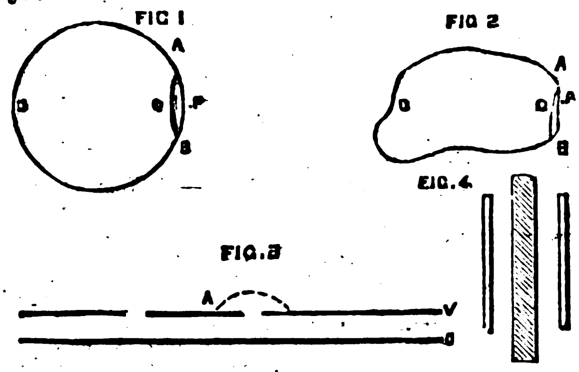
To compare the capacities of two condensers (*i.e.*, to measure the spec. ind. cap. among other things) one may electrify both to the same potential, and then compare their quantities with a torsion balance, $\frac{s}{S'} = \frac{Q}{Q'}$. Or, better, we may electrify one to a measured potential $V = \frac{Q}{S}$, and then share the charge with the other, and measure their joint potential, $V' = \frac{Q}{S + S'}$, when we have $V S = V'(S + S')$ or $\frac{S}{S'} = \frac{V'}{V - V'}$

If the two condensers are alike, except that the dielectric in one is air, and the other a medium, with sp. ind. cap. K, then $S = K S'$.

Cascade.—If a Leyden jar has the capacity S_1, and another jar of capacity S_2 be interposed between its outer coating and the earth (cascade), then its capacity is decreased to $\frac{S_1 S_2}{S_1 + S_2}$. For, at first, when its outer coating is earth-connected, a quantity, Q, produces a rise of potential $V_1 = \frac{Q}{S_1}$ in the inner coating; but, when the second jar is interposed, the same quantity, Q, passes into it, and produces a rise of potential, $V_2 = \frac{Q}{S_2}$ in *its* inner coating, and also in the outer coating of the first jar. So the potential of the inner coat of the first jar rises to $V_1 + V_2$ (the quantity, of course, still remaining Q), and its capacity is, therefore, now $S = \frac{Q}{V_1 + V_2} = \frac{Q}{\frac{Q}{S_1} + \frac{Q}{S_2}} = \frac{S_1 S_2}{S_1 + S_2}$.

Lemma.—Discharge of an insulated jar by alternate contacts.—Let the two plates A and B of a condenser of capacity S have respectively capacities S and S′ — A free in space; then, when B is at potential O, and A at potential V, the charge on A is $Q_A = (S + S_1)V$, and the charge on B is $Q_B = -S_V$; so $Q_B = -\frac{S}{S' + S} Q_A$. But, when A is to earth and B at potential V, we should have $Q_A = \frac{S}{S + S'} Q_B$.

Now, let there be a jar containing Q′ on its inner coating, and $-\frac{S}{S + s}$ Q, or Q′ on its outer. Touch inner coating so as to reduce its potential to zero, the charge on the outer remains Q′, but that of the inner becomes $-\frac{S}{S + s'} Q' = \frac{S^2}{(S + s')(S + s)} Q_1 = Q_2$. The discharge from the inner coating is, of course, $Q_1 - Q_2$. Now touch outer coating and you obtain a discharge $Q_1' - Q_2'$ where $Q_2' = -\frac{S}{S + s} Q_2$. On touching inner coat again you get $Q_3 = -\frac{S}{S + s'} Q_2'$, the discharge being $Q_2 - Q_3$, and so on, calling the factor $\frac{S^2}{(S + s')(S + s)} = \lambda$. We may write the successive inner charges $Q_1, \lambda Q_1, \lambda^2 Q_1, \lambda^3 Q'$, &c.; and the successive *outer* charges $Q'_1, \lambda' Q'_1, \lambda^2 Q'_1, \lambda^3 Q'_1$, &c., the nth *discharge* being $\lambda^{n-1}(\lambda - 1)Q$, where Q is Q_1 for inner, and Q'_1 for outer coating. The *work done* in charging a body to the potential V with a quantity Q is $\frac{1}{2}QV$.



For, to carry Q units of positive electricity to a body whose average potential was $\bar{V}$, would, by definition of potential, consume $Q\bar{V}$ units of work; but, if you start with a body at O potential and raise it to V, since the potential increases arithmetically with Q, its average potential is $\frac{1}{2}$ V. So the work done is $\frac{1}{2}$ Q V. And this is the *energy* of the charge.

We may notice that $\frac{1}{2}QV = \frac{1}{2}\frac{Q^2}{S} = \frac{1}{2}V^2 S$; showing that with a condenser of fixed capacity the energy increases with the square of the charge.

Hence, when the charge of a jar is halved (say by sharing it with an empty similar jar) half the energy is lost in the spark of sharing, and the two jars together possess the other half between them—*i.e.*, each a quarter.

To find the common potential of two jars when connected with one another. When separate we have $Q_1 = S_1 V_1$ and $Q_2 = S_2 V_2$. When together the potential is $V = \frac{Q_1 + Q_2}{S_1 + S_2} = \frac{S_1 V_1 + S_2 V_2}{S_1 + S_2}$

The charges are respectively $S_1 V$ and $S_2 V$.

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When two charges are shared in this way there is a loss of energy. For the total energy at first is

$$\tfrac{1}{2} S_1 V_1^2 + \tfrac{1}{2} S_2 V_2^2,$$

but after sharing, it is $\tfrac{1}{2} (S_1 + S_2) V^2 = \tfrac{1}{2} \frac{(S_1 V_1 + S_2 V_2)^2}{S_1 + S_2}$

So, if w is the loss of energy,

$$2 w (S_1 + S_2) = (S_1 V_1^2 + S_2 V_2^2)(S_1 + S_2)$$
$$-(S_1^2 V_1^2 + 2 S_1 S_2 V_1 V_2 + S_2 V_2^2) = S_1 S_2 (V_1^2 + V_2^2 - 2 V_1 V_2).$$

Hence $$w = \tfrac{1}{2} \frac{S_1 S_2}{S_2 + S_2} (V^1 - V_2)^2.$$

A necessarily positive quantity. This is the energy of the sharing spark.

ANSWERS TO QUERIES.

7. "J. Davies" asks in what does potential, as applied to electricity, differ from potential as applied to energy? He should consult some handbook of telegraphy—say Preece and Sievewright's; but, meanwhile, he may be helped by the following rough explanation. The term has the same signification applied to both, namely, the efficient power capable of being but not yet exerted. As applied to energy, it takes into account mainly the resistance to be overcome. Electrical potential often involves more complex conditions. The measure of electro-motive force is represented by the difference of electrical potentials at two points, and, when earth is used, both are referred to the electrical potential of the earth. Strictly speaking, the potential value of a current will be determined by the difference between the differences of potentials at the two points. J. L.

8. If "J. W." is under eighteen years of age, and is in other respects eligible, he can obtain a nomination for the Postal Telegraph service by applying to the Secretary, General Post Office, London. J. L.

QUERIES.

17. Will you explain to a puzzled party how the two opposite poles of an electro-magnet attracts the plate on the hammer of an electric bell, which is *charged* with *one* of the same kind of electricities of one of the poles of the said electro-magnet? We imagine that the two opposite poles should neutralise each other in respect to a body *charged* with an electricity of the kind of one of the poles. A SUBSCRIBER.

THE PHYSICAL SOCIETY—JUNE 8TH.

[CONTINUED.]

THE ELECTRICAL PROPERTIES OF BEES' WAX AND LEAD CHLORIDE.

Professor REINOLD at the last meeting of the Physical Society read a paper by Professor W. E. Ayrton, of the Imperial College of Engineering, Tokio, Japan, on "The Electrical Properties of Bees' Wax and Lead Chloride." The author stated that, in the two papers by Professor Perry and himself on Ice as an Electrolyte Result, read before the Physical Society, they showed that both the conductivity and specific inductive capacity of $\left\{ \begin{array}{c} \text{ice} \\ \text{water} \end{array} \right\}$ increased regularly without discontinuity in passing from several degrees below the freezing point to several degrees above it. They drew attention to the fact that, in consequence of the absorbed charge in water being immeasurably greater than the surface charge, they could not hope by any method of experimenting to properly compare the true specific inductive capacity with the index of refraction for light of infinitely long waves, so that, in fact, the only support that Professor C. Maxwell's electro-magnetic theory of light could hope to derive from these experiments must be based simply on the fact that in $\left\{ \begin{array}{c} \text{ice} \\ \text{water} \end{array} \right\}$ both the specific inductive capacity and the index of refraction increase as the temperature rises. At the meeting of the Society in November, at which the second of their two papers was read, Professor G. Foster mentioned that he was gathering together all the results obtainable, connecting specific inductive capacity with index of refraction. He (Professor Ayrton) therefore begged to forward, as a contribution to this collection, the following results of some further experiments which he had been making on this subject. For the last two years his attention had been turned to wax as a good material for electrically testing, especially in regard to the connection which, in their paper on the "Viscosity of Dielectrics," communicated to the Royal Society, they pointed out existed between high specific inductive capacity and low specific resistance. He therefore had constructed a large condenser, consisting of many sheets of letter paper soaked in melted bees' wax, with alternate sheets of tin-foil. After the condenser was built up in the usual way, melted bees' wax was poured in, the plates squeezed together, and the whole shut up in a fairly good water-tight wooden box. The condenser was buried several feet under ground to insure uniformity of temperature, connexion being made with the insulated coating by a piece of Atlantic cable core and with the other coating by a piece of bare copper wire. After this condenser had been buried for a short time it showed the apparently abnormal condition of diminution of resistance by electrification. This phenomenon then formed the subject for special investigation with this condenser. As beeswax is one of the few substances in which the index of refraction for light increases in passing from the liquid to the solid state, it seemed important in connection with the electro-magnetic theory of light to carefully measure the specific conductive capacity of a wax condenser as it was gradually cooled through the solidifying point. A small shallow clean copper box, 19 centimetres long by 17 centimetres wide, was therefore lined with a sheet of letter-paper 0·036 centimetres thick, previously well soaked in melted beeswax. A clean copper disc 12·8 centimetres in diameter was placed on the top, weighted down, and the dish filled up with melted wax. This condenser, A B was heated in an oil bath, *C D*; E and F are holes for the insertion of thermometers, of which the bulbs were just above the wax condenser; G is an opening through which the insulated electrode, H, of the condenser may protrude without touching the oil bath. A wooden stand, W W, supported the condenser in the middle of the bath, and a glass vessel, V, holds strong sulphuric acid to keep the inside space artificially dry. The bath is closed by a double door, which is made to fit well by a strip of leather inserted between it and the bath. The condenser having been inserted, the bath was heated to about 90° C, and kept at that temperature for some time; the lamps were then removed, when the temperature fell very slowly. The capacity was then measured (several observations being made at each temperature) by charging the condenser with 75 Daniells cells joined in series and discharging it through an exceedingly delicate Thomson's reflecting galvanometer. The curves obtained (on three different days) did not give the same capacity for the same temperature, but, considering, first, the very small capacities that had to be measured, and, secondly, the difficulty of accurately determining the temperature of a non heat-conductor like wax, even when enclosed in the oil bath, the discrepancies in the curves were not to be wondered at. One fact, however, was very striking in all three curves, and that was the *rise* in capacity as the temperature very slowly fell from about 80°. to 60°. and the subsequent diminution in the capacity on a still further diminution of the temperature. Probably, had experiments on capacity been made when cooling from a much higher temperature, there would have been observed, first, a gradual diminution in capacity due to cooling, down to about 80° C.; then they had the rise of capacity in the wax solidified at about 60° C.; and, lastly, they saw the subsequent rapid decrease on further cooling. Now, this was precisely in agreement with the changes known to occur in the index of refraction for light, and hence the interest of these experiments. As there was always a small electromotive force in the wax condenser, and, as the vibrations of the galvanometer needle were, as usual, damped by the air vane, he used for calculating the capacity the formula developed by Professor Perry and himself for employment in such cases ("A test for Determining the Position of a Partial Discontinuity without Earth-fault," by Professors W. E. Ayrton and John Perry, page 12). It might, of course, be at once objected that the rise in capacity, as the work cooled from about 80° C., to 60° C. was perhaps due not to any change in the specific inductive capacity, but merely indicated that the distance between the copper plates of the condenser was slightly diminished by the wax shrinking on solidifying. This solution, however, was impossible, since, although a sudden expansion of the wax on solidifying, if such an expansion existed, might have separated the plates, it was unlikely that the contraction which really occurred could have brought them nearer together than the thickness of the paper by which they were separated when the wax was liquid. Nevertheless, partly to obtain additional evidence on this point, and partly to measure specific resistance, or resistance per cubic centimetre, of beeswax at different temperatures, he made ten distinct sets of experiments, occupying many days, on the conductivity of wax. In these experiments the wax condenser was heated up to about 130° C., and a current sent through it with the seventy-five Daniells cells in series. The temperature was kept constant at about 130° C., until the galvanometer deflection had reached its maximum, when it was considered that the wax had acquired the temperature indicated by the thermometer. The temperature was then allowed to fall very slowly, and frequent readings of the galvanometer and thermometer were taken. The results were shown by a diagram. In no curve was there *the slightest appearance* of a rise of conductivity at the melting point, which would probably have been obtained had the copper-plates approached one another in appreciable distance on the wax solidifying. They might, therefore, conclude that in the previous experiments the rise in the capacity at melting indicated a true increase in the specific inductive capacity coincident with an increase in the index of refraction for light. As regards apparent increase of resistance by electrification, which, as mentioned, he observed during repeated experiments, extending over some months, with the wax condenser buried under ground, the general conclusions arrived at were that, not only did the conductivity usually increase by electrification, but that it steadily increased day by day—a result indicating that the wax was deteriorating, probably from damp penetrating through the joints of the wooden box, in spite of leather having been inserted between the different parts of the wood before they were screwed together. This conclusion appeared to be correct, since on digging up the condenser and keeping it near a fire for many days, it regained its original high resistance. The damp must, therefore, not only have entered through the joints in the wood, but through some small cracks that were observed in the mass of wax when the condenser was opened, and it was probably due to this damp that the peculiar effects of polarization were observed similar to those noticed by the Comte du Moncel when testing stones, and by Mr. T. Warren in certain insulating oils. He now made a number of experiments with lead chloride as a dielectric—a substance to which his attention was particularly drawn by some remarks of M. Buff Ann. Chem. Pharm. cx., s. 258, 1859, in which he said that this substance conducts electricity like a metal that is without decomposition, a conclusion, however, which at first sight would appear to be negatived by certain experiments of Herr Wiedemann, published in Pogg. Ann. c. liv., 318—320, from which he found that the resistance of lead chloride diminished by increase of temperature. He (Professor Ayrton) first had made a small carbon box containing a carbon plate, but prevented from touching it by three small pieces of clean glass. The carbon plate had a carbon electrode attached to it, the whole being cut out of a solid piece of carbon, so as to have the shape of an inverted "T." Into the box lead chloride was poured in a fused state until it covered up the plate, but leaving the carbon electrode of the plate protruding for connection with the battery. The whole was then allowed to cool very slowly. The outer part of the carbon box and the end of the carbon electrode were now electrotyped, and copper wires soldered on, the junction of the carbon and copper being quite clear of the lead chloride. [The results observed with this condenser were given in a table showing twelve experiments on different dates.] In addition to the resistance of the condenser being measured while the battery was con-

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nected, time readings were also taken with the galvanometer and the discharge from the condenser after the removal of the battery, as well as time readings with an electrometer of the electromotive force in the condenser producing the discharge. As, however, diminution in the discharge and deflection was in each case quite regular, and curves were not given, it was interesting to observe, in the preceding table, that in *every* case there was a diminution of resistence by electrification, although in some cases there was an increase during the first minute. Looking at the first group of tests taken between November 13 and 15, they saw a gradual increase in the resistance day by day. Looking, also, at the second group of tests made between November 21 and December 1, they likewise saw a steady daily increase in the resistance, but, in the interval between November 15 and 21, when no tests were made, there appeared to be a decided diminution in resistance. Considering, however, that the tests taken on Nov. 13, and at the beginning, and on December 1, at the end of the investigation, gave almost identical results, it could not be concluded with certainty that there was any decided deterioration taking place in the lead chloride. But, on breaking up the condenser, the lead chloride was found to contain many small holes, so that it was possible that damp might have collected in these. This solution, however, would, at first sight, appear to be rather improbable, since the condenser, both when being tested, and when not tested, was kept in an atmosphere kept partially dry with sulphuric acid. Some fresh lead chloride was prepared in the same way as before—that is, by precipitating from a solution of lead acetate with a solution of common salt, and carefully washing the precipitate several times with distilled water. But, the new condenser, made with the carbon box and plate, was found to have a resistance of only two megohms at 16° C., and, unlike what was experienced in the former case, the resistance in all the experiments was now found to increase by electrification. This, however, was probably explained by the fact that whereas in the previous case 30 volts electromotive force was used now, only one volt was employed, so that decomposition—whether of the lead chloride itself, or of the damp, which, after decomposition, might act on the chloride—was probably not produced. Some preliminary temperature tests were now made, and, in accordance with Herr Wiedemann's results, he found that the resistance diminished with elevation of temperature. The condenser was now left in an atmosphere dried with sulphuric acid from December 21 to January 7, when it was found that the resistance had increased to about 15·6 megohms at 70° C. A large number of measurements of the conductivity at different temperatures, using the same oil bath for raising the temperature, were now made. The different experiments gave results nearly agreeing. The representative curve was approximately logarithmic, that is, the ratio of the difference of the logarithms of the conductivities to the difference of temperatures was approximately constant. Thinking that possibly the method previously employed for making the lead chloride by precipitating it from a solution of lead acetate with a solution of common salt might have introduced traces of some salt of lead other than the chloride, the following method was now employed for making another supply of the chloride. From a clear solution of lead nitrate a precipatate was formed with colourless hydrochloric acid, and the precipitate well washed with distilled water. A third condenser was now constructed, three small pieces of glass 0·225 centimetres thick being used to separate the carbon plate from the box. The connections with the box and plate were made as before by first electrotyping the carbon with copper, and then soldering on copper wires, the junctions of the carbon and copper not being in contact with the lead chloride. A condenser was also made with a copper box and a copper plate, the two being well coated with graphite to protect them from the action of lead chloride, and separated from one another by three small pieces of glass 0·135 centimetres in thickness. Tests of conductivity were now made at different temperatures with both condensers, 0·075 volts being employed with the carbon, and 7·5 volts with the copper condenser, or sometimes 2·2 volts with the latter. With the carbon condenser and with the smaller electro-motive force the resistance was found to increase with electrification, whereas, with the copper condenser and with the electro-motive force 2·2 volts, the resistance diminished with electrification, and with 7·5 volts this diminution became much more rapid, these results being observed at both high and low temperatures. In the earlier experiments with this copper condenser the diminution was regular, whereas later on it proceeded irregularly; but, on the whole, it might be said that, when an electro-motive force not exceeding one and three-quarters volts was employed, there was an increase in resistance with electrification such as is usually experienced with gutta percha and with ordinary dielectrics, while when the electro-motive force exceeded this limit there was either a regular or an irregular diminution of resistance by electrification, the results apparently not depending much on whether carbon or copper coated with graphite was used for the plates of the condenser. As this limiting electromotive force appeared to be about the same as that necessary to decompose water, he thought they might fairly conclude that the diminution in resistance was due to a decomposition of the damp (which appeared to be contained in the lead chloride even when careful means were taken to dry it), and to the products of the decomposition acting on the chloride.

TELEGRAPH SHARE LIST.

Amount of Issue.	Amount of Share.	Paid on Share.	Company.	Reserve as per last Report.	Dividends calculated at rate per cent. per annum. 1875. %	1875. %	1876. %	1876. %	1877. %	1877. %	When Payable.	Prices. 1875. Highest.	1875. Lowest.	1876. Highest.	1876. Lowest.	1877. Highest.	1877. Lowest.
£3,254,580	Stock	100	PAnglo-American	Deferred receiving no dividend until 6 per cent. has been paid to Preferred.		year.	5	4†	3	5	† Div. 5 % per ann. for quarter ending Dec. 31, 1876, 2% for quarter ending Mar. 31, 4 % for quarters ending June 30 and Sept. 30, 6 % for quarter ending Dec. 31, 1877, and 4 % for quarter ending March 31, 1878.	75½	51½	68¾	53	62¼	52
1,872,710	Stock	100	Do. Preferred B		—	—	10	2	6	6		Crtd	1876.	93	75	88¾	79
1,872,710	Stock	100	Do. Deferred A		—	—	Nil.	6	Nil.	4		Crtd	1876.	44	29	38	25½
1,300,000	10	All	Brazilian Submarine	120,000	5	5	5	5	5	5	Quarterly.	7¼	6	7¼	5¼	6¼	5¾
160,000	10	All	Cuba (Limited)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60,000	10	All	Do. 10 per cent. Preference	—	—	—	—	—	—	—	—	—	—	—	—	—	—
116,373	10	9	Direct Spanish (Limited)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
58,430	10	All	Do. 10 per cent. Preference	—	—	—	—	—	—	—	—	—	—	—	—	—	—
65,000	20	All	Direct United States	Nil.	—	Nil.	Nil.	Nil.	Nil.	5	Quarterly.	13	7	11½	6¼	13¾	9½
359,700	10	All	Eastern (Limited)	110,000	5	year.	5	5	5		*a*Jany., April, *July*, Oct.	8	6⅝	7⅝	5	8¼	6½
232,000	100	All	Eastern 6 per cent. Debentures	—	—	—	—	—	—	—	—	—	—	—	—	—	—
200,000	100	All	Do. 5 per cent. Debentures	—	—	—	—	—	—	—	—	—	—	—	—	—	—
700,000	10	All	Do. 6 per cent. Preference	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,997,500	10	All	Eastn. Exten. Australasia & China	125,404	5½	year.	5	year.	5	year.	*a*Jany., *April*, July, Oct.	8¼	7	7½	5½	8	6½
320,000	100	All	Eastn. Exten. 6 p.c. Deben. (1875)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
192,680	10	All	German Un. Tl. and Tst.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,500,000	10	All	Globe Telegraph and Trust	Nil.	5	7 4-5	4½	7 5-6	3¾	7 6-7	*b*Jany., April, *July*, Oct.	6¾	5½	5¼	4½	5¼	4½
1,500,000	10	All	Do. 6 per cent. Preference		6	6	6	6	6	6	Jany., April, July, Oct.	10½	9¾	10½	9½	10½	9¼
150,000	10	All	Great Northern	85,543	5⅝	year.	6⅝	year.	6⅝	year.	5 % intrm. Jan. 1, July 1. Final Dividend April.	11½	7½	9¼	7	8	7
			Shares to Bearer, or can be Regstrd.														
—	25	All	Indo-European	—	—	—	—	—	—	—	—	—	—	—	—	—	—
120,000	10	All	Mediterranean Extension (Lmtd.)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
32,000	10	All	Do. 8 per cent. Preference	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	18	All	Reuter's (Limited)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
65,000	10	All	West India and Panama	16,000	Nil.	Nil.	Nil.	Nil.	1	1	‡ Converted from a 10 % into a 6 % 1st Preference.	4¼	1⅝	2½	⅝	3⅝	1⅝
34,563	10	All	Do. 6 per cent. Preference		7/6ac	year.	10/ac	year.	6‡	6		12	9	11	7	11	7½
67,500	20	All	Western and Brazilian	7,793	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Half-yearly.	18¼	9½	10½	4¼	5½	4½
$1,500,000	$1000	All	Western Union Telegraph 7 per cent. First Mortgage Bonds	—	7	7	7	7	7	7	May, November.	108	102½	109½	105	113	106
£1,030,000	200	All	Do. 6 per cent. Sterling Bonds	Redeemable by annual drawings at par.	6	6	6	6	6	6	March 1, September 1.	93	86	98	89	101	94

a Year ends March 31st. Interim Dividend of 5 per cent. Final dividend in July. *b* Year ends July 18th. Final dividend in July.

Companies.	Business Done. Th., 13.	F., 14.	Sat., 15.	Mon., 17.	Tu., 18.	Wed., 19.
Anglo-American (Lim.).	62½	62½	62½	63⅛, ½	63⅝, ¾	64, 3¾
Do. Preferred	92½, ⅝	—	92⅝, ¾	93	93½	93½
Do. Deferred	—	—	35¾	35⅛, ½	35⅞, 36	—
Brazilian Submarine	6 15-16	7⅛, 1-16	7	7 1-16, ⅛	—	—
Cuba (Limited)	acc 9¾	—	—	—	—	9½, ⅝
Do. 10 p. c. Prefrnce.	—	—	—	16	—	—
Drct. Span. 10 p. c. Pref.	—	9 13-16, ⅞	—	—	9⅞, ¾, ⅞	—
Drct. U. S. Cable (Lim).	acc 13⅞, ¾	14⅛, ⅛, ⅜	14⅛, ⅛	14⅛, ⅜	14⅛, ¼	—
Eastern (Limited)	7⅝, acc 7⅝	7 11-16	7⅝, 9-16	7⅝, 9-16	7 11-16, 9-16	7⅝
Do. 6 pr. cnt. Deben.	—	—	—	103½	—	—
Do. 5 pr. cnt. Deben.	acc 103½	—	—	—	—	—
Do. 6 p. c. Prefrnce.	11¾, ac 11¾	11⅜	11¾	12	—	—
Eastern Extension, Austral., & China (Lim.).	ac 7 13-16, ⅞, ¾	7⅞, ¾	—	7⅞	7 13-16, 15-16	7⅞
Globe Tl. & Trst. (Lim.).	acc 5 5-16	5⅛	5 7-16, ⅜	—	5⅛, ⅜	5⅛, ⅜
Do. 6. p. c. Prefrnce.	acc 10⅞, 11	11	11⅛, 11	11	11, 10⅞, 11	11, ⅛
Great Northern	8⅞, ac 8 15-16	9	8⅞	—	9⅛	9, ⅛
Indo-European	—	—	—	—	20⅞, ⅛	—
Reuter's (Limited)	—	—	—	10⅞, ⅛	—	—
W. India & Pan. (Lim.).	acc 2⅜	2⅜	2 7-16	2⅜, 9-16, 7-16	2⅜, ⅛	2⅜
Do. 6 p. c. 1st Prefnc.	acc 8⅜	8⅜	8 13-16	8⅜	8⅜, 9, 8⅞	—
Do. 2nd Preference.	—	—	—	8⅜	—	—
*Western and Brazilian (Limited)	acc 5 5-16	5⅜	5⅛, ⅜	5⅛	5	—

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NOTES.

Duplex Extension.—We understand that Dr. Muirhead is just leaving England for Madras in order to duplex the Madras-Penang section of the Eastern Extension Company Cable.

The Criminal Code.—Injuring Electric Telegraphs.—Most of our readers know that a Bill has been prepared on this subject, and, among the numerous amendments suggested, we notice that "the *maximum* punishment for injuring electric telegraphs is raised from two years' hard labour to seven years' penal servitude."

Electric Illumination.—The Parisian Gas Lighting and Heating Company have published in several financial papers an identical article intended to reassure its shareholders in face of the progress of electric lighting. This article contests the possibility of solving the problem of electric lighting at a low price, and affirms that in any case the monopoly of the Parisian Gas Company runs no risk.

German Telegraphs. — The Saxon Government has brought in a Bill relating to the purchase of several private railway lines by the State. The purchase price of the line of the Valley of the Mulde has been fixed at 18,600,000 marks nominal, in 3 per cent. rentes of the Kingdom of Saxony; that of the Chemnitz-Würschnitz line at 2,600,000 marks; of the Gössnitz-Gera line at 5,050,000 marks; of the Annaberg-Weipert line at 2,222,000 marks; and of the Mehltheuer-Weida line at 450,000 marks—a total of 28,822,000 marks, or £1,416,160.—*Berlin Bourse Gazette.*

The Precipitation of Copper.—Mr. N. S. Keith, in a paper read before the American Institute of Mining Engineers, gives the following plan, which he devised to obtain the copper from the mother liquors which had become too impure during the manufacture of sulphate of copper to yield merchantable sulphate. He places scrap iron in an ordinary porous cell, which is filled up with sulphate of iron, free from copper, and this is placed in a larger vessel, which contains some of the mother-liquor, and a sheet of metallic copper. On connecting the iron and the copper by a wire, external to the solutions, so as to establish an electric current, the deposition of the copper and the solution of the iron as sulphate at once commence, and in about 36 hours the liquor in the experiment was completely freed from copper, which was deposited on the copper sheet, as a beautiful velvet-like coat, pure and coherent. The amount of iron dissolved was the atomic equivalent for the copper deposited—viz., 56 of iron to 63·5 of copper.

An Electric Awakener.—Mr. F. Peppard is the inventor of a curious contrivance for awakening a sleeper at any required hour. The apparatus is to be affixed to an ordinary clock; it is so arranged that when the hour-hand of the clock touches a button, an electric circuit is completed: the minute-hand passes over the button without effect. There are a series of holes for the different hours, into any one of which the button can be pushed, according to the time selected for awakening. The completion of the electric circuit may ring a bell, or sound any other of the numerous ordinary methods of alarm. But this contrivance has a yet more effective method for arousing a deaf man or any sleeper who is willing beforehand to prepare himself for a shock. A bracelet is provided which can be put on the wrist at the time of retiring; to this flexible wires are attached, and the electric discharge will pass through it at the appointed hour. A man who could lie down to pleasant dreams with such an apparatus fastened to his wrist would naturally need the violence of an electric shock to awaken him.

Grove's Gas Battery.—Mr. H. F. Morley, in the *Philosophical Magazine*, says that his experiments show that at least a part of the current in the gas battery is due to dissolved gases. By arranging a battery with plates wholly immersed, and raising these until the platinum cuts the surface, it is shown that the increase of current consequent thereupon is too small to necessitate the assumption that a new force is thereby brought into action. Strength of current suddenly falls when resistance is suddenly increased, but it rises again to nearly its former value. So, when resistance is diminished, the current rises suddenly, but afterwards falls to nearly its former value. In the first case, the diminished current causes a diminution in the amount of gas used; the electromotive force, and therefore the current, being thus raised. In the second case, the increased current uses more gas; the electromotive force is therefore diminished, and the current falls. It is further shown that the current is directly as the pressure. This seems to prove that there is really no antagonistic force kept up by hydrogen attached to the positive wire, as supposed by Gaugain.

Improvement in Telegraphy.—According to the *New York Tribune*, Mr. Loring Pickering, an editor and newspaper proprietor of San Francisco, has obtained a patent for a "machine to telegraph a page at once." It is stated that an entire page of a newspaper may be transmitted in from fifteen to thirty minutes, the copy delivered being ready for use by printers. From the information that has reached us, the process is based on a principle devised some years ago; but in this case, instead of writing being transmitted, the stereotype plate itself is utilised. The depressions between the letters and lines are filled up with a non-conducting composition, the plate is bent and placed on a cylinder capable of revolving rapidly, and electric fingers are made to trace over every part of the surface. When the fingers traverse the non-conducting composition the current will be interrupted, but it will flow while the fingers are in contact with the exposed metallic surfaces. The receiving instrument is a similar cylinder, revolving at about the same rate, and the characters are reproduced by the action of electric fingers on a chemically-prepared paper, or, as our authority says, ordinary paper.

Influence of Heating on the Resistance of Hard-drawn Wires.—M. O. Chivolson, the author of a paper on this subject in "Carl's Repertorium fur Experimental Physik," finds that by heating hard-drawn platinum-iridium wire its resistance diminishes about 3 per cent., the resistance increasing again slightly on cooling. The heating is effected by the passage of the current. Zinc wire and aluminium wire heated by means of a gas-burner diminish in resistance about 2 per cent. Aluminium-bronze wire diminishes 8 per cent., but increases about 3 per cent. on cooling. Silver-copper alloy, containing 82·9 per cent. silver and 13·4 per cent. copper, diminishes in resistance about 12 per cent., but on cooling returns to its original resistance. Steel at a dull red heat decreases about 5 per cent., and by continued heating another 8 per cent., the resistance increasing again on cooling. Iron diminishes ·33 per cent. at red heat, but increases at higher temperature to 5 per cent. over its normal resistance. By heating to red heat, hard brass wire is reduced in resistance more than 8 per cent.; by stronger heating the resistance is increased about 1 per cent. Hard-drawn copper

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wire diminishes in resistance at a temperature of red heat about 3 per cent.; on cooling an increase of ·5 per cent. occurs; stronger heating increases the resistance until the initial value is even surpassed. Platinum behaves somewhat similarly, diminishing, then increasing.

THE MICROPHONE IN THE PULPIT.—The *Halifax Guardian* says that a young gentleman, well known in connection with a firm of telegraph engineers in the town, has contrived to have his sermons at home. He placed a microphone in the pulpit of a chapel in this town, and connected it, by means of a private telegraph line, with a house over a mile distant. Every part of the service was distinctly heard by the owner of the house, with the exception of a few words rendered indistinct by the preacher becoming a little excited, and shaking the microphone, the presence of which he never dreamt of, or he might have been somewhat nervous at the idea that his sermon was being conveyed away he knew not whither. So faithfully did the microphone do its work that the chapel-keeper was heard to close the doors after service, walk up the aisle, and up the pulpit steps, in conversation with some else. During the week experiments have been made in the schoolroom of another chapel, and the singing of the scholars was transmitted and retransmitted over a number of telegraph lines with remarkable clearness. The idea is about to be put to practical use, the gentleman already referred to having given instructions that his house should be connected with that of a gentlemen near, in order that an invalid may hear the service from one of the churches in the town.

ANOTHER CURIOUS APPLICATION OF ELECTRICITY.—Electricity has been applied to stripping photographic films from glass plates. Photographers know full well that there is scarcely any substance so electric in its nature as a collodion film, and a dry film may be made to adhere firmly to a glass surface if it is simply stroked by the hand to excite it electrically. M. Boivin believes that the only adhesion of a collodion film to glass, in the ordinary way, is due to its electric state, and it is only when the electric condition is destroyed that the film is repelled so thoroughly that it may be lifted from the plate without difficulty. An excited film certainly adheres very firmly, and can only be peeled off the glass with difficulty, and clings to one's hands and around one's fingers with a disagreeable tenacity. When charged, however, with positive electricity the film comes from the glass immediately, and one has no difficulty in getting it to leave the plate. It is said that, if we simply cut round the edges with a knife, and then charge the film, first with one kind of electricity and then with another, the collodion image will leave the glass without further trouble. This is certainly a novel application of electricity.

THE ELECTRIC LIGHT—LAMP INVENTED BY M. REYNIER.—In reference to this lamp, M. de Parville makes the following observations in this *Bulletin Français*:—"With *four Bunsen elements*, we have just seen a very pretty electric light produced. The elements, which can be charged in five minutes, may be stowed away in a corner, in the cellar, &c., and one may be certain of having, during three or four hours, a splendid, vivid, and at the same time—if it be sifted through a suitable globe—a soft and rosy light. This is evidently an important step taken in the difficult problem of the electrical illumination of apartments and small workshops. Let us give a brief description of the new system: When a platinum wire is interposed in the circuit of a battery, it may be sufficiently heated to emit a white light. If the wire be replaced by a thin rod of gas-carbon, this also may be heated so as to produce a dazzling light. Such is the principle of the electric lamps acting by incandescence, of which various forms, more or less practical, were shown in Paris some years ago. The shortcomings of these lamps were due to the fact that, in order to obviate the combustion of the carbon rod, this was enclosed within a vessel from which air was excluded. The rod was then but slightly acted upon; but this arrangement necessitated very hermetic receivers and a somewhat complicated system. A young electrical engineer, M. Reynier, has hit upon the idea of dispensing with all these complications, and of simply allowing the carbon to be consumed. The carbon, raised to a red-white heat by the electric current, is consumed by oxidation like the wick of a lamp; but its cost is not so great as to prevent its being replaced in the same manner. Thus is obtained an extremely simple electric lamp, which is managed with the same facility as an ordinary lamp. If much light is required the wick is turned up, *i. e.*, the heated portion of carbon rod is augmented; if less light is needed, the wick is turned down. If the lamp is to be extinguished, the circuit is broken; if it is to be re-lit, a knob is turned, and the light flashes forth. Nothing can be simpler. The system is quite elementary. A rod, or rather a needle of carbon, from twenty to thirty centimetres long, and from one to two millimetres thick, is held at one end by a metal rod, which tends to descend by its own weight, and at the other by a carbon wheel in a vertical position. The carbon rod is pressed strongly, whatever may be the consumption of the material, against this wheel, which is made to turn slowly. The current raises the carbon to a white heat at the point of contact of the extremity of the rod with the carbon wheel. The expenditure for charcoal is about 10 centimes per hour. Thus, a rod costing 30 centimes (3d.) will last for three hours. And thus, without any magneto-machine, or steam engine, but with a little battery of four to six elements, any-one can have the electric light in his own home. The lamp which we saw in action is far from being perfect, since it is the first of its kind, the first realisation of a conception which may be of great future importance. It is, however, to be perfected with the least possible delay; and it will certainly be regarded as a boon to have the means of utilising a powerful electric light without incurring any outlay for plant.

NEW TELEPHONIC INVENTIONS.—Mr. Joseph P. Noyes, of Binghamton, N. Y., writes to the *Tribune*, describing a new device for increasing telephonic sounds. He introduces into the electric current a V-shaped apparatus, consisting of two strips of somewhat flexible material, joined or in electrical connection at their lower ends and slightly parted at the upper. The material is a conductor of very high resistance. To each upper end a wire of the circuit is attached. It will be seen that, if the V is gradually closed, the current will pass over less and less of the poor conductor. This is facilitated by rounding the inside edges of the strips along the line where the contact is to take place. Mr. Noyes then applies a diaphragm so that its movements of vibration (by sound waves) shall open and close the V. By this device, it is stated, far louder sounds are obtained than with the ordinary telephone. At Philadelphia, Professors Edwin J. Houston and Elihu Thomson, of the Central High School, have for some months past been endeavouring to effect a relay of telephonic messages from one circuit to another. Professor Hughes's construction of the microphone has now enabled them to solve this problem, as that contrivance can be made to repeat on a new circuit the most delicate vibrations that have started from a Bell telephone. The new relaying apparatus has been shown at the Franklin Institute, and was operated there satisfactorily.

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THE TELEPHONE.

BY BROWN AYRES.

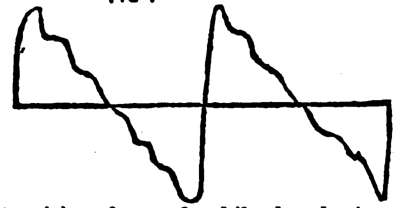
Probably no invention ever attracted more universal and interested attention than the telephone, and it is safe to say that none was ever more deserving of it, whether we regard the instrument in its intrinsic interest from a scientific standpoint, or whether we look at it in its purely practical bearing. The public, by a legion of newspaper articles and public lectures, has become moderately familiar with the general construction and operation of the instrument, but no one seems as yet to have considered it in its theoretic aspects, nor to have given to the public many very remarkable facts that can hardly have failed to have attracted the attention of any one who has worked to any considerable extent with the instrument. An outline of this theory, and a few of these facts, it is the purpose of the writer to present in the present paper, with the hope that it may at least stimulate others more fully prepared for the task to give the subject more thorough attention.

The complete understanding of the action of the telephone, covering, as it does, some of the most refined portions of dynamics, would require mathematical processes of the greatest complexity and difficulty; but a clear understanding of the general principles of the operation of the instrument, with enough of the quantitative relations involved to give us definite ideas in regard to its action, need not be inconsistent with a limited knowledge of the higher mathematical processes.

In attempting to form a conception of the action of the telephone, we must keep constantly before our minds the mutual relations of pitch, intensity, and quality in the sensations of sound, and their relations to the corresponding amounts of energy involved in the various transformations through which the energy of the sound wave passes between its initial and final states as kinetic energy of atmospheric vibration. We may, to give breadth to our view of the subject, regard the instrument in a generalized form. As such, we shall find that it consists of three essential parts: Firstly, the mechanism which receives the energy of the vibrating air, *e.g.*, the plate; secondly, the mechanism for transforming the energy of sound motion so received into an equivalent of electric and other energy, or for regulating the development of electric energy in an external source; and lastly, the mechanism for reconverting the electric energy into aerial undulations. I have pictured the instrument thus in its generality, because in special points the various telephones differ, and the present method of construction can hardly be expected to be rigorously adhered to.

The requirement for an articulating telephone is that the working margin of the electric current and the action of the mechanism shall be so related that the sound given forth at the distant end of the line shall be, in relative pitch, intensity and quality, an accurate reproduction of the sound initially produced. In all forms of telephone yet devised, as we shall directly see, the strength of the transmitted current is in direct proportion to the kinetic energy of an air particle engaged in the production of a given sound, and is independent of the pitch; so that for the purposes of this paper we may say that the requirements of an articulating telephone are that at any moment the working margin of current strength shall be directly proportional to the loudness of the sound (physically considered) and independent of its pitch. To convey a more concrete conception of this we may draw a curve (Fig. 1), whose ordinates will

FIG 1



represent intensities of sound, while the abscissæ will represent periods of time. Any such curve, if it be harmonic in its character, may represent a musical sound. Now, the requirement of a speaking telephone is that this same curve should represent the varying current strengths if the ordinates be currents while the abscissæ are times, as before.

These conditions are fulfilled by several different instruments to a greater or less degree of approximation. The various telephones yet devised may be classified as follows:—

Class I. Telephones by induced currents (produced by the relative motion of a conductor and magnet).

(*a*). Those in which the magnet moves relatively to the conductor.

(*b*). Those in which the conductor moves relatively to the magnet.

(*c*). Those in which both move simultaneously.

Class II. Telephones by *variation* in a voltaic current. A variation, according to Ohm's law $\left(I = \frac{E}{R}\right)$, can only be produced by varying E or R. Hence of this class there are:

(*a*). Those that vary the electromotive force.

(*b*). Those that vary the resistance of the circuit.

Class III. The Electrostatic telephone of the writer, to be directly described.

The equation of the motion of a particle engaged in the production of any simple tone,* is

$$y = a \sin\left(\frac{2\pi t}{\tau} + \alpha\right), \qquad (1)$$

where a and τ are the aptitude and period of the vibration respectively, and α is a constant depending on the time that has elapsed from the commencement of the motion until the moment we begin to reckon. The variable velocity of the particle is

$$\frac{dy}{dt} = a.\cos\left(\frac{2\pi t}{\tau} + \alpha\right)\frac{2\pi}{\tau}. \qquad (2)$$

For our purpose a sufficiently exact expression for the kinetic energy of the vibrating particle while producing any note can be reached as follows:—The total energy of the vibration at any time consists of two parts, kinetic and potential, the sum of which is constant. The whole of it will be manifested as kinetic energy as the particle passes its point of equilibrium. At this point $y = 0$, hence $\sin\left(\frac{2\pi t}{\tau} + \alpha\right) = 0$,

$$\therefore \cos\left(\frac{2\pi t}{\tau} + \alpha\right) = \pm 1, \text{ and } \frac{dy}{dt} = \pm\frac{2\pi}{\tau}a.$$

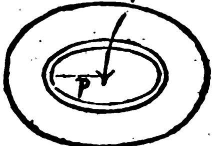
But the kinetic energy is $\frac{1}{2} m v^2$. $\therefore \frac{1}{2} m v^2 = 2 m \frac{\pi^2 a^2}{\tau^2}$. (3)

Then the whole force exerted by any collection of particles vibrating synchronously will be $\Sigma \frac{m v^2}{2} = \Sigma \frac{2 m \pi^2 a^2}{\tau^2}$.

From which we see that, with a given mass of vibrating particles, the kinetic energy varies as the square of the amplitude divided by the square of the period; or, what is the same thing, as the square of the product of the amplitude by the number of vibrations in a unit of time.

In all telephones yet devised, the aerial undulations are received on a flat disc of thin elastic substance—such as mica, rubber, or iron—and hence this portion of the theory is common to all forms. The complete investigation of the relations between the applied forces and the resultant action of the plate in the telephone forms one of the most complex dynamical problems in the whole range of science, but an expression for the relation between the variables, sufficiently exact for our purpose, may be reached in the following manner. Let us treat the problem as one of shearing stress (Fig. 2):—

FIG. 2



Let P = applied force, Δ = deflection of plate, ρ = variable radius, t = thickness of plate, e = coefficient of transverse elasticity.

Then,† according to the law of shearing stress,

$$P = 2\pi t e \rho . \frac{d\Delta}{d\rho}; \qquad (4)$$

whence we have $d\Delta = \frac{P}{2\pi t e} . \frac{d\rho}{\rho}$;

and integrating between the limits r, the radius of the plate, and r_1, the radius of the area on which the force is applied, we have

$$\Delta = \frac{P}{2\pi t e} . \log\frac{r}{r_1}; \qquad (5)$$

From equations (3) and (5) we see that within the elastic limit of the plate the deflection will be proportional to the kinetic energy of the sound wave.

"It can be shown that no forced vibration can have any harmonic component of a period which does not exist amongst the periods of the harmonic component of the imposed motions or forces."‡ The plate, then, must follow every motion of the alternately condensed and rarefied air particles. Though I have only given an expression in equation (3) for the kinetic energy of a single note, it will readily be perceived that in the case of a complex motion at any given moment the energy will be repre-

* Donkin, "Acoustics," p. 47.

† Wood, "Resistance of Materials," p. 215.

‡ Donkin, "Acoustics," p. 89.

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sented by that expression. The discussion of the general equation would be too lengthy for insertion here, but can easily be found by those interested. (See Donkin's "Acoustics" and Rayleigh's "Theory of Sound.")

The theory of the three divisions which I have made in the first class of telephones is the same; hence an exposition of the theory of the Bell Telephone will answer for the other two. By the Bell Telephone we will understand that arrangement of a vibrating plate of magnetic matter before the pole or poles of a magnet—temporary or permanent—around which pole or poles wire is wound after the manner of an electro-magnet. In a general way, the explanation of its action could be given somewhat in this wise: The motion of the plate, by disturbing the distribution of the magnetic field, causes a motion of the magnetic lines of force, which, cutting across the wires of the helix, cause a current to be induced in these wires. This current, passing over the line, causes a variation in the force with which the plate at the further end is attracted, and the variation imparts to the plate a motion depending on the varying strengths of the incoming current. The motion of the lines of force can be readily observed if we cover the poles of a rather powerful horse-shoe magnet with not too fine iron filings, and move the armature to and fro before the poles. It can also be readily shown by means of the floating magnetic needles described by Prof. A. M. Mayer, in the *Am. Jour. Sci. and Arts*, for April, 1878.

The theory of the action is as follows:*

If m be the magnet strength, and the induced magnetism of the plate, which, of course, is a function of m, be $q\,m$, where q is some constant, then the attractive force between them will be

$$\frac{q\,m\,.\,m}{p^2} = \frac{q\,m^2}{p^2}.$$

where p is the distance between the poles of the magnet and plate. Now, if the plate be moved to any new position, p^2, from its initial position, p_1, work will be done by or against the attractive force.

$$\text{This work} \quad = q\,m^2 \int_{p_2}^{p_1} \frac{d\,p}{p^2} = q\left(\frac{m^2}{p_2} - \frac{m^2}{p_1}\right);$$

but $\frac{q\,m^2}{p_1}$, $\frac{q\,m^2}{p_2}$ are the values for the potential at the positions p_1, p_2 respectively; hence

$$\text{Work} = q\,(V_2 - V_1);$$

or the work done will be manifested by a variation in the potential.

The potential at the time will evidently depend on the state of the magnetic field.

$$V = f(\gamma) = M\gamma.$$

But on the difference of potential at any two instants will depend the electromotive force of our induced current:

$$V_2 - V_1 = M_2\gamma_2 - M_1\gamma_1 = E = I\,R,$$

$$\text{hence} \qquad I = \frac{V_2 - V_1}{R} = \frac{M_2\gamma_2 - M_1\gamma_1}{R}, \qquad . \quad . \quad (6)$$

or, the strength of the induced current will be equal to the difference in the potential of the system at two given instants, divided by the resistance of the circuit. The quanity $M\gamma$ can be interpreted as the number of lines of force passing through the coil, M depending for its value on the position of the coil and plate with reference to the magnet, and γ being the number of lines of force in unit area of the equipotential surface at unit's distance from the pole at the instant that the quantity $M\gamma$ is observed. It will readily be seen that γ depends on the magnetic strength, while M depends on the arrangement and adjustment of the instrument as well as the intensity of the sound wave impinging on the plate. With any given arrangement of magnet, coil and plate, any change in $M\gamma$ will be dependent on the position of the plate, that being the only movable portion of the instrument. Hence if A be the position of the plate at any instant

$$M\gamma = f(A) = k\,A$$

$$\text{and} \qquad M_2\gamma_2 - M_1\gamma_1 = k\,(A_2 - A_1). \qquad . \quad . \quad (7)$$

or, the variation in the potential is proportional to the amplitude of vibration, hence the strength of the induced current will be proportional to the amplitude of vibration, and therefore proportional to the kinetic energy of the sound wave.

This current traversing the wire will cause a variation in the magnetic strength of the distant telephone, either by augmenting or diminishing it according to the direction of the current. The variation will be sensibly proportional to the strength of current, as will be shown later. Hence a force will be exerted on the distant plate proportional to the kinetic energy of the initial wave of sound. The intensity of the emitted sound will therefore, at any instant, be in direct proportion to the initial sound. It will be observed that in the above discussion no notice is taken of the pitch of the note, whatever it might be, except where it enters the expression for the kinetic energy of the initial sound wave; but it will readily be seen that whatever be the motion, if the distant plate is at every moment attracted with a force varying as the motion of the first plate, all the conditions for the transmission of sounds, however complex, are fulfilled. It remains for us to examine what are the requirements in the receiver that its plate may have a force exerted on it directly as the strength of the incoming currents.

Let m be the magnetism of the magnet, which, if produced by a current, will be directly proportional to it, $= a\,\gamma$.

Let K = induced magnetism of the plate $= f(m) = q\,(m)$.

Assume the initial distance of the centre of magnetism of the plate from that of the magnet $= p$. Then the attractive force $F = \frac{q\,m\,.\,m}{p^2} = \frac{q\,m^2}{p^2} = \frac{q\,a^2\,\gamma^2}{p^2}$; or the attraction is as the square of the current, as was demonstrated by Joule.

Suppose m to undergo any variation $\Delta\gamma$, due to a variation in γ, then

$$F_1 = \frac{q\,m^2}{p^2}(\gamma + \overline{\Delta\gamma})^2 = \frac{q\,a^2}{p^2}(\gamma^2 + 2\gamma\,\overline{\Delta\gamma} + \overline{\Delta\gamma}^2).$$

$$\text{Hence,} \qquad \overline{\Delta F} = \frac{q\,a^2}{p^2}(2\gamma\,\overline{\Delta\gamma} + \overline{\Delta\gamma}^2).$$

If $\overline{\Delta\gamma}$ be very small $\overline{\Delta\gamma}^2$ can be neglected without appreciable error, in which case

$$\overline{\Delta F} = \frac{2\gamma\,q\,a^2}{q^2}\,\overline{\Delta\gamma}. \qquad . \quad . \quad . \quad (8)$$

From which we conclude that, while the total strength is proportional to γ^2, the variation, if small, is proportional to $\Delta\gamma$; or, in other words, if the magnet is entirely magnetised and demagnetised by the incoming currents, the attractive force will be proportional to the square of the current; while, if it be a permanent magnet, whose strength is varied, it will be proportional to the current. But if $\Delta\gamma$ be large, so that $\overline{\Delta\gamma^2}$ will have an appreciable value, the force will be augmented by the term $\overline{\Delta\gamma^2}$. Now, in an articulating telephone, in order that the relative loudness of the component tones of a sound be preserved, the attractive force must vary as the current. Hence, for the receiver of an articulating telephone, a permanent magnet must be used, and, in order that $\Delta\gamma$ shall be sufficiently small, the permanent magnet should be as near saturation as possible. Hence loudness, arising from large margin of attractive force, will be fatal to perfection of articulation. In the Bell telephone these requirements are beautifully fulfilled by the use of the same instrument as sender and receiver. This result also explains to us the imperfect working of the original form of Bell's instrument, with the electro-magnet. The magnet was too far from saturation by the constant current; hence the attractions more readily followed the law of Joule than that of simple proportion, and the articulation was correspondingly imperfect.

[TO BE CONTINUED.]

* For a more complete discussion see Cumming, "Theory of Electricity," p. 210; Maxwell, "Electricity and Magnetism," Vol. II., p. 176.

MACHINE RHEOSTATIQUE.

M. Niaudet, in giving an account of this machine, mentions that M. Planté has now in action 800 secondary cells. The E.M.F. of one of these cells is, in round numbers, 3 volts. Thus the 800 cells of Planté are nearly equivalent to 2,344 of the chloride of silver elements of De la Rue. The E.M.F. of the secondary battery is variable from the above maximum, and decreases constantly as it is discharged. The quantity of electricity, however, forced into these cells during the time of charge is enormous, so that experiments can be carried on for a long time: thus, a Geissler-tube can be illuminated for three and a half hours. When M. Niaudet witnessed the experiments of M. De la Rue, he noticed the steadiness of the stratifications in the exhausted tubes, and was surprised to see the same thing occur in the experiments of Planté. In the *Machine Rhéostatique*, a large cylindrical commutator is so arranged that in one position all the left-hand plates of the condensers are connected together by springs touching a bar of copper, and so are the right hand plates. In that situation the connection is established with 800 secondary cells, and the condensers are charged. When the commutator turns 90 degrees, the springs are brought to touch a number of separate knobs connected in cascade, as is the case in the commutator of his secondary battery, and, consequently, the condensers are joined in intensity, like the elements of a battery, and the discharge takes place in the shape of a spark. The sparks, like those obtained from a frictional machine, are all in one direction. The machine has another advantage over coils;

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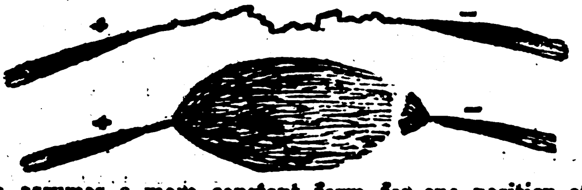
the current of the battery is never short circuited, and all the electricity supplied by it is sure to go in sparks; while with the Ruhmkorff coil you close the circuit of the battery on the primary wire, and you lose a portion of the current which it is not easy to determine, but which is considerable. In a recent article in *La Nature*, M. Planté thus speaks of the machine:—

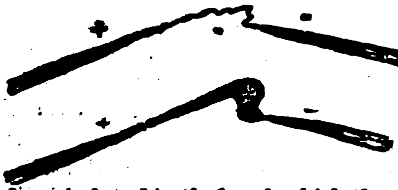
"The effects produced by the instrument which I have described under the name of *machine rhéostatique* much resemble those of electrical machines and induction coils; but they present, at the same time, some peculiar features, which it may be well to point out.

"In order to study them, I made use of machines composed of ten, thirty, forty, and fifty condensers, with plates of mica. By using at first a machine of ten condensers, charged by the secondary battery of 800 couples, we obtain, with a rapidity of fifteen revolutions per second, a series of brilliant sparks of from thirteen to fourteen millimètres in length, which succeed one another rapidly enough (to the number of thirty per second) to form a continuous line of fire, accompanied by the same sound as that of the sparks of an inductive coil furnished with a Leyden jar.

"When we turn slowly, so that the spark flashes out only at intervals, it presents numerous and irregular sinuosities. With machines of thirty and of forty condensers, which give sparks of four and five centimètres, these sinuosities rise above or sink below the straight line which would join the two points of the conductor. Fig. 1. But, if we turn the machine rapidly, the spark



then assumes a more constant form for one position of the branches of the conductor. This form consists, when the angle comprised between these branches is very obtuse, of a line of fire starting in a straight line in the direction of the positive branch, rising considerably above the negative point, and returning to it by a curve, describing at this point numerous sinuosities (Fig. 2.)



"The same form is found in the brush which the machine gives when the distance of the points is increased by one or two millimètres. A luminous conical jet springs from the positive pole, traverses about three-fourths of the distance to the negative pole, and bends round towards the short brush formed around the negative point. With rheostatic machines giving sparks of four and of five centimètres, the brush presents a stalk terminated by a luminous egg-shaped sheaf, more or less branching, like that of electrical machines (Fig. 1). The form of these sparks and brushes, more distinct than that of induction coils, is due especially to the fact that the instrument produces a current of electricity always in the same direction, which renders it easy for us to measure the tension of it with Thomson's electrometer and to compare it with that of electrical machines. The length of the sparks seems to increase in simple proportion to the number of the condensers; but we cannot ascertain this in a rigorous manner, because of the inequality of thickness of the insulating plates, and of the variable effects which result from them. The light produced in *vacuo* is more intense than that of electrical machines, in consequence of the great quantity of electricity at work, and, when the movement of rotation is sufficiently rapid, it is as vivid and continuous as that of induction coils. Geissler's tubes, and the phosphorescent tubes of M. Edmond Becquerel, are illuminated in a brilliant manner; but the absence of stratifications is to be remarked even in the tubes which produce them very distinctly with Ruhmkorff's coils. Neither do we observe the blue sheath which surrounds the negative pole; the light is purple throughout the whole extent of the tube, and fills it entirely as with the induction coil furnished with a Leyden jar. This effect must proceed from an excess of tension, for, by considerably diminishing that of the source of the electricity employed to charge the rheostatic machine, the stratifications and the blue sheath appear; they are also produced directly with the secondary battery of 800 couples, the tension of which is far less than that of the machine. The rheostatic machine produces generally all the effects of electrical machines and induction coils, and these effects appear not to be disturbed in any sensible degree by the variations of the hygrometric condition of the atmosphere. The production of the continuous spark or of the brush is accompanied by a strong odour of ozone. Each of the poles may produce sparks on the approach of bodies in contact with the ground. The effects of the electrical whirligig, or currents of air produced at the points of the conductor, are easily exhibited.

"The instrument in question would present only a theoretical interest if it were necessary always to have recourse to a secondary battery of 800 couples to show its effects. Therefore I endeavoured to produce them with a much weaker source of electricity, and I succeeded in doing so by increasing the number of condensers and by decreasing as much as possible the thickness of the insulating plates. With a machine of 50 condensers, with very thin mica plates, supported by frames of caoutchouc hardenened with gutta-percha, we may obtain continuous sparks of six millimètres by employing only 100 secondary couples, and we may even render a tube of rarefied air luminous by charging the machine with a secondary battery of 30 to 40 couples. With this comparatively weak source we perceive the stratifications and the blue sheath around the negative pole.

"It was an interesting experiment to try to completely transform by means of the rheostatic machine a certain quantity of dynamic electricity accumulated by secondary batteries, and to ascertain approximately the time necessary to exhaust the whole charge under the form of static effects. Amongst other experiments I will mention the following:—A secondary battery of 40 couples without any residual charge, but ready to store up the slightest chemical action of a primary, was charged during fifteen seconds by two of Bunsen's elements, and afterwards put in action on the rheostatic machine; it was necessary then to turn the instrument more than a quarter of an hour to exhaust this charge by illuminating a Geissler's tube.

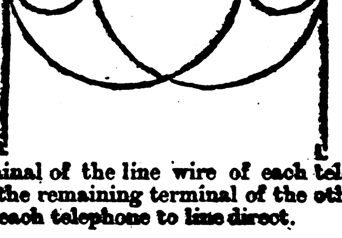
"From this it follows that, with the quantity of electricity taken up by the secondary battery during the space of ten minutes (which is about the time needed to accumulate in it, without sensible loss, the action of the primary), we might render a tube of rarefied air luminous during more than ten hours."

TELEPHONE EXPERIMENTS AT MALTA.

Mr. Robert Portelli, the superintendent at Malta of the Eastern Telegraph Company, while experimenting some time back with the telephone, arrived at very satisfactory results by an ingenious method of joining up two of these instruments, and applying one to each ear.

We are assured by gentlemen who have tried it that Mr. Portelli's plan is a great improvement, not only upon the single telephone, but upon the ordinary method of using one at each ear. By this new arrangement the sound is quite doubled, rendered much more distinct, and seems to be brought nearer.

In order to enable those who may feel disposed to try Mr. Portelli's plan, we give below a diagram of the connections.



From the terminal of the line wire of each telephone a short wire is taken to the remaining terminal of the other instrument, thus connecting each telephone to line direct.

STUDENTS' COLUMN.

Errata.—By some unfortunate means, a proof from which corrections should have been made was mislaid, and several serious errors are to be found in Dr. Lodge's paper last week. Thus, in line 4, conductors should be condensers; line 5, after density, insert $= -\rho$; line 14, read $= t\sqrt{\frac{8\pi F}{A}}$; in second paragraph, read K for *k*, S for *s*; in third paragraph, line 3, S and S′ should be *s* and *s*′; and for A read when; similarly, in line 5, the second *s* is a small letter, and Ss should be S V; line 6, second *s* in the denominator is a small letter; line 7, insert — after =. The other corrections are easily made.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

We cannot undertake to return drawings or manuscripts, and must, therefore, request Correspondents to keep copies.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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NOTICE TO EDITORS.

We shall be happy to exchange with the Editors of Scientific journals who receive the first numbers of THE ELECTRICIAN.

Nous serons heureux de faire l'échange avec Messieurs les Rédacteurs des Journaux scientifiques qui recevront les premiers muméros de L'ELECTRICIAN.

Es wird uns ein Vernügen sein mit den löblichen Redactionen der deutschen und anderen continentalen Journäle und Zeitscriften, denen die ersten Nos. des ELECTRICIAN *zu Händen kommen möchten auszutauschen.*

I Signori Editori di giornali scientifici che riceveranno i primi numeri dell' ELECTRICIAN *ci faranno cosa gradita accettando il cambio che loro offriamo.*

DISPUTED INVENTION OF THE MICROPHONE.

We are glad to have the opportunity of printing the following commnnication:—

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to your article headed "Disputed Invention of the Microphone," I enclose you two messages sent to New York, which I hope you will publish.—Yours, &c.,

June 25, 1878. W. H. PREECE.

To NORVIN GREEN, NEW YORK.

Please give following message to Associated Presses and to Ashley:—

"Pray give the most absolute and unqualified denial to the statements made by Edison respecting me. Hughes has not brought out any thermopile. His microphone is quite a different instrument to Edison's telephone. It was worked out without any communication with me, or information imparted by me, in any way whatever. I knew nothing of it until it was shown to me, together with Professor Huxley and Mr. Norman Lockyer. I am in no way whatever a coadjutor of Hughes. "W. H. PREECE."

"I emphatically endorse every word of the above message.
"D. E. HUGHES."

A NEW FEATURE OF METROPOLITAN LIFE.

John Bull is proverbially Conservative, not to say obstinate, in his habits. "What was good enough for his father is good enough for him" is apt to be his first dogged answer when any change is recommended to him, and he even takes a pride in this slowness to adopt improvements. And, no doubt, there is something good at the bottom of it; but, certainly, it puts the worthy gentleman to a good deal of discomfort and inconvenience which the rest of the civilised world has learned to get rid of. This is well seen by all of us who have travelled in America, that most go-ahead of continents. Who, for instance, can fail, after experience, to recognise the superiority of the American system of dealing with the baggage of travellers. You send to an "express" office; your trunks are fetched from the house; a numbered badge is strapped on to each article of which the corresponding portion remains in your possession; and you know that, if you do not care to reclaim them for weeks, all your belongings will be kept safe for you at the other end of the journey, which you may then accomplish at your leisure and convenience. Before you arrive, the train will be boarded by the agents of other express companies, to whom you may give up your checks, with the address of your hotel, and stroll to it unencumbered and with a quiet mind. While here, though it may be said that, on the whole, our system does not work so badly, the prudent passenger cannot sleep sound in the exotic and still-suspected Pullman car, since he is never secure that some gentleman of the Kurr or Benson type may not be playing the foreign count in his best shirts or his new tourist suit. But, if we ask why the American system is not introduced, the only reasons to be given are —first, that our railway officials don't care to take the trouble; second, that the public, being used to the old ways, rather like them as adding a certain zest of risk to a journey, just as the African adventurer really relishes the chance of being chased by a gorilla, or eaten by a lion; and, lastly, that it would be a change, which, to most minds among us, is quite decisive.

Electricity has given some rude shocks to this contented disposition to let things remain as they are; yet we are still behindhand in making use of all the service which it offers us. In all large American cities there are little boxes on the lamp or telegraph posts, the purpose of which may have puzzled the observant stranger. As soon as a fire breaks out, the first citizen, with his wits about him, runs for the key of the nearest box, or breaks the glass, and by a touch sets at work the machinery within, which instantly informs the firemen of the "trouble" and its locality, and, moreover, in some places, rings an alarm bell heard all over the city, and understood by the number of its strokes to refer to such and such a quarter, so that the well-warned inhabitant knows at once if it be necessary to leave church or theatre and post off to look after his property. But, on this side of the Atlantic, if Captain Shaw or some other energetic official demands such increased facilities, our ratepayers take him for a very Oliver Twist of unreasonableness. Something, indeed, is going to be done by some municipalities, and, as soon as a great conflagration has roused us to action, something, no doubt, will be done. The wonder is that nothing has yet been done in this direction, and in other directions opened out by electrical science. Why, even Germany, the chosen home of paternal Government and bureaucracy, has taken to the telephone more energetically than we Britons who think, if we do not trouble ourselves much to say, that we are the most enlightened people on the face of the earth.

What, then, will the British public say to a new feature now to be added to their daily life—that is, if they chose to make trial of its advantages? The Exchange Telegraph Company—which is also prepared, upon due encouragement, to deal with the question of street fire-alarms—is about to introduce into the metropolis what they term the "call system," by which the use of the telegraph will be brought to our homes even more closely than on that morning, some eight or nine years ago, when we rose to find the telegraph boys in their new uniform swarming in and out of every post office. We are not at liberty to go into a full description of

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the contrivances which the Company, with a wise eye to possible competition, prefer to keep a little mysterious for the present; but a pamphlet just published gives a clear description of all that the public have any business to know about the proposed system. The houses of subscribers are to be connected by a closed circuit with the nearest office of the Company, which is not to be more than a quarter of a mile distant. At one end of the communication thus established will be a staff of messengers ready for instant service; at the other, an automatic transmitting instrument, so simple that a child can work it, and, by the way, the children are likely to work it with a vengeance if due precautions be not taken on this score. By merely pressing a button, the householder, or man of business, can in three minutes call to his door a smart boy in uniform, prepared to to do his bidding at an outside charge of eightpence an hour. If a boy be held not sufficiently trustworthy—and there are some errands upon which not even an enthusiastic member of the School Board would care to employ one of these mercurial pieces of humanity—you can have a commissionaire, or an agent of still more responsible character, to transact any kind of business for you. You may also call a cab, a policeman, an experienced person provided with a hand-pump or fire extincteur; and it is intended to provide communications with the public police and fire stations. The subscriber, who is thus efficiently served by day, may also have the safety of his premises provided for by night. The Company will see that patrol signals are regularly recorded, thus watching the watchman who might otherwise be dozing over a comfortable pipe and glass. Or, if no watchman were employed, the communications would be so arranged as to give instant alarm at the office on any forcible entry of the protected premises, while a rise of temperature beyond a certain point, as would happen in the case of fire, would at once be detected and attended to. Experience will, no doubt, suggest other developments, and the Company are sanguine enough to hope that before long every well-appointed house will have electricity laid on, as much of course as gas and water.

This system has for some time been in successful operation in America. An article in an American paper gives us some notion of the working of the "District Telegraph Company" in New York. In one district it has two hundred and fifty offices; and, at one station, we are told of from two hundred to four hundred messages being delivered during business hours. An amusing list is given of the various errands on which the messengers are employed. It is plain that Brother Jonathan makes full use of the advantages of the institution. Assistance was promptly had on such emergencies as "pipes burst," a drunken servant to be removed, a lodger to be ejected, "a mad dog in the kitchen," an abusive cabman, an office to be minded, traces of burglars discovered, and so on. Besides the ordinary commissions, which we can readily imagine, the Company's boys were sent to distribute circulars and bills, to fetch a pail of water, to order dinner, to get a set of teeth, to make a fire, to fetch a shoeblack, to pull corks, to go to the pawnbroker's or to the savings' bank, to bring watch, spectacles, and key, to carry flowers to a funeral, to escort a lady to the station, to procure bail, to find a witness, to remind a voter, to secure places in Pullman car, to hold a horse, to take charge of a dog, to get change, to match silk, to fetch the doctor, likewise the *doctoress*, to take a child home, and, of all things in the world, *to borrow a wig*. They seem even to have been employed as extemporary *aides de camp* to carry military orders; and it is possible they may take a small part in the diplomatic service of the country. We do not know if Sir Charles Reed and Mrs. William Grey would agree with us, but we are inclined to think that for a sharp boy to be in the service of such a company would be in itself a not unfruitful education.

Such are some of the conveniences which the new system offers to the public. Its ready adoption in America is probably due to the want of domestic servants so much felt there, and it may not take such quick root in our own social circumstances. But, whether we like it or not, we are coming to much the same state of things, and before the first Chinese *washerman* sets up in Kensal Green we might as well see for ourselves what can be done with this new method of economising by organising labour. There is no reason to despair of a day when much of the work of our pompous Johns and pert Sallies will be done for us by merely mechanical agencies, never giving warning, requiring not even a Sunday out, and bringing no suspicious "cousins" about our premises. The new "Call System" to be offered for our adoption in a few days s a step towards this devoutly-to-be-wished consummation, and we hope that this wonted indifference to, not to say dread of improvements, will not prevent Mr. John Bull from giving it a fair trial, both in his house and his place of business.

ON THE STUDY OF ELECTRICITY AS A PROFESSIONAL PURSUIT.

BY THOMAS T. P. BRUCE WARREN.

IV.

Wherever a battery is to be fitted up, it is not only requisite to obtain rigid support for it, but also easy access to every portion of it, so as to examine any of the cells, or for supplying the necessary materials for replenishing.

If the room is sufficiently large, it is better to fit the cells up in racks so as to get all round the battery. If the space is small, shelves or racks may be secured to the walls, but of such depth that the cells at the back can be easily reached. Against a wall it is well not to have the cells more than three deep, as inspection is not so easy as when fitted up in the middle of a room.

On board ship, all that we have previously said with respect to the battery must be carefully attended to, and, as it is more difficult to secure good insulation and firmness than on shore, it is necessary to adopt a different method of mounting the cells and battery. A short time ago the cells were fitted up and packed into trays with sawdust or cotton waste, so as to keep the cells apart. The great disadvantage of this is that, if the contents of a cell were spilled, or liquid dropped about, it would be absorbed by the sawdust or cotton without disclosing the fact, and sooner or later the cells, instead of being insulated from each other, would be surrounded with a damp mass of sawdust or cotton. A little time ago I recommended the following plan, which was a great improvement over this, and acted, I, believe, very well. It was used with the Leclanché battery. A stout vulcanised rubber washer was stretched around the glass jar a short distance from the bottom, and another near the top. A sheet of good vulcanised rubber was placed on the bottom of the trays, so as to insulate the cells. In this way the cells could be tightly packed without risk of being broken, the cells and battery were well insulated. More recently I have given a better form to the marine battery, which is equally serviceable and convenient for any testing purpose. It is thoroughly portable, is easily kept in good order and insulated, and is tolerably constant even for three years; if not neglected, the end to its usefulness comes about by the tendency which the copper solution has to ascend and so clog the sawdust with reduced copper.

This battery is described in the 'Journal of the Society of Telegraph Engineers,'* but its convenience and constancy are sufficient to tempt me to bring the same before the general student, with the new additions which have been made to it, and which practice has proved to be beneficial.

The little glass cells used some years ago for burning night lights in were among the most economical forms of glass cells. Wide-mouthed bottles and lengths of glass tubing sealed at the bottom end with a cork boiled in paraffin wax have been used. Latterly I have seen cells made by rolling paper soaked in paraffin around a "fourer" used for making Roman candle moulds.

* Vol. II., page 432.

Ebonite tubing fixed into melted paraffin makes very cheap and convenient cells, and may be easily taken to pieces, cleaned, and again set up.

Fig. 1 shows the general plan of the trays for receiving the cells. A mahogany or teak tray about four inches deep, 10 inches wide, and 22 inches long (inside measurements), will hold very conveniently, and with sufficient space for paraffin, 10 cells about four inches diameter and five inches high. In fitting the battery up the paraffin is economised by filling up a portion of the intercellular spaces with pieces of wood, which should not extend more than half an inch below the completed tray. A little melted paraffin is first poured into the trays so as to cover the bottom to the depth of half an inch; this is allowed to set perfectly hard.

Ten tin cans are soldered together on their upper edges, lengthwise and across, so as to keep them firmly together. These cans are a little larger in diameter than the largest cell to be fitted up. They are placed on the top of the layer of hardened paraffin and weighted so as to keep them from rising when the melted paraffin is poured in. As soon as it has begun to set the weights should be removed, otherwise the cans may sink into the layer below, which will become softened from the heated paraffin. When the paraffin is perfectly hard a little boiling water is poured into each of the tins or moulds, which renders their removal easy. Our trays then contain 10 receptacles in solid paraffin, as it were, into which the cells will fit.

A A' is the tray, B B' are the blocks of wood used to fill up a portion of the space to economise the paraffin. This can be done without any detriment to the insulation. A tray of the above dimensions will require about twelve pounds of paraffin, which, by the blocks being inserted, will be reduced to four or six pounds. M M' are the tin moulds soldered together as shown. C C' are the spaces occupied by the cells. The blocks being all covered with paraffin, the top of the tray presents an even surface of paraffin.

If in replenishing the battery a little liquid were spilled, it could be taken up with blotting paper. In the event of a cell being broken, its contents are prevented from damaging the insulation of its neighbours, and being confined in its proper receptacle its action is uninterrupted. These trays are then fitted into stout racks so that they can easily slide in and out when required. A strong button or screw holds them in their places. See Fig. 2. If a rack containing fifty of these cells be deflected or shaken violently, whilst the current from them is in use for insulation tests on a long length of cable, no alteration whatever is perceptible. The suitability of the battery for use on board ship was tested in this way. Two thousand miles of india rubber cable were joined up and an insulation test made with every hundred cells, kept on for one hour, during which time the racks were moved, so as to show any inconstancy of current due to shaking, &c., the deflection was constantly watched, and no cells were put on board which did not show a steady and constant current for this time. From the impossibility of being able to test long lengths of highly insulated wire with any form of battery in use at the time, I was led to design the following modification of the Menotti cell, see Fig 3, and about two thousand of these cells were used on board ship for four years without giving any trouble. After each voyage the battery was cleared up, and each set of ten cells tested on an electrometer against a standard element of Mr. Latimer Clark's construction.

A little well washed sand is placed at the bottom of the glass cell, so as to allow the copper disc to rest evenly and without the chance of enclosing air on its underneath surface. The terminal wire is well insulated, and is brought up near the side of the glass. Over the copper disc is packed, rather tightly, some finely sifted pine sawdust saturated with a solution of sulphate of copper, four pounds of the salt to one gallon of water. This should extend about one inch above the disc. Immediately on the top of this is well rammed down some sawdust, which has been previously boiled in a strong solution of sulphate of zinc. A solution being made, saturated at the boiling point, and diluted with an equal volume of water, sufficient depth is left for the zinc plate or casting, and the hemp and paraffin packing which serves to keep the zinc in its place and prevents evaporation. A glass tube passes through the centre of the zinc, saw dust, &c., and rests upon the copper disc, enabling solution to be added as required. It is better to replenish the battery with solution only, unless it is required for hard work, as "copper" or "loop tests." Crystals may then be added cautiously.

In the general laboratory a battery is sometimes required only for a short time at, perhaps, long intervals, and I know of no form of battery so suitable as this. Where economy is an object, the glass cell may be dispensed with, its place being supplied by the paraffin receptacle. In this way the student may supply himself with a very serviceable battery containing 500 or more cells for comparatively little cost.

The cost of electrical apparatus will, I have no doubt, frighten many who contemplate the study of this science. The student should bear in mind that costly apparatus is not necessary for the acquirement of a good knowledge of its application to telegraphy.

The use of reflecting galvanometers, electrometers, and similar pieces of apparatus is at present a luxury only to be thought of when one is fortunate enough to get into an electrician's office. It appears to me that there is a sad want of some organisation to secure the establishment of technical museums. I am confident that most of our leading manufacturers would willingly assist to carry out some well devised plan.

Whilst on this part of the subject I may remark that I do not think the electrician has much to regret at the dissolution of the loan collection of scientific instruments at South Kensington. If the Society of Telegraph Engineers, for instance, would take upon itself something of an educational department, I believe there would be no difficulty in obtaining assistance from those who are interested in electrical research.

Much may be gained from reading descriptions, &c., of apparatus, but more will be gained by seeing the same in use than a whole day spent in admiring the same when confined in a glass case. An experiment, in almost every case, leaves an indelible mark upon the mind. Wherever a fact can be proved or illustrated by experiment I would advise the student, in whatever branch of study, avail yourself of the very first opportunity of witnessing by experiment that which reading assumes you must accept.

Technical education must in a few years take some practical development, and those societies which act as the centres of applied branches of knowledge ought to be the means of diffusing this knowledge. A slight pressure on our Government ought to be sufficient to allow a few of the spare instruments and apparatus belonging to the Telegraph Department being placed at the disposal of some educational institution.

FIG. 1.

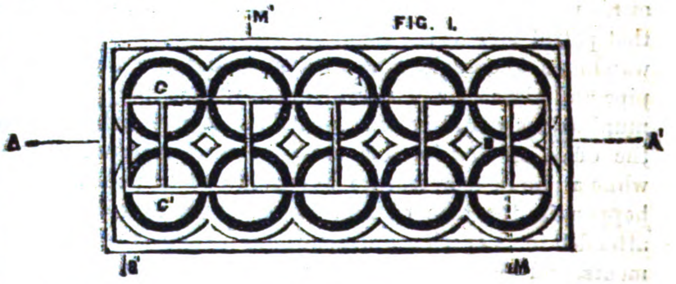
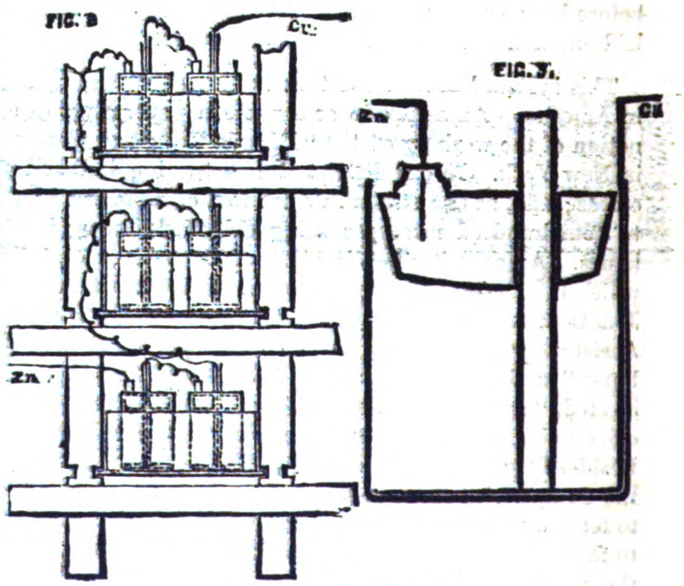


FIG. 2. FIG. 3.



[TO BE CONTINUED.]

Telegraph Extension.—The telegraph has been extended from Wainfleet to Skegness, and the wires are now open for messages.

Post Office Telegraphs. — The Government Telegraphs Bill is to be opposed by the Corporations of Liverpool, Manchester, Birmingham, and other leading towns. The proposed abrogation of the power of local authorities to prevent the erection of telegraph posts and wires being strongly disapproved.

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A MOST DELICATE THERMOSCOPE.

Thomas A. Edison, of New York, is inclined to dispute certain discoveries recently made in England. We were among the first to publish an account of the delicate "thermopile" (a better term, which we here adopt, is "electrical thermoscope"), which forms part of the discoveries of Professor D. E. Hughes. Professor Hughes's discovery was in this case the result of an accident. He had been making certain experiments with glass tubes, and for the moment, not having a glass tube at hand, he took up a quill, and fashioned it for his purpose. The result he expected to see was not obtained; in fact, the experiment failed, but the failure drew attention to some other important facts. The quill contained carbon, and under the action of heat the quill expanded more than the carbon. The differential action resulted in the increase of the circuit resistance, and so influenced the current and the action of the galvanometer. We are now informed that Mr. Edison long since constructed an instrument for measuring to an astonishing exactness the smallest variations of temperature. In his experimental researches he discovered that, under certain electrical conditions, carbon was exceedingly sensitive. The slightest change of temperature affects the expansive and contractile properties of certain bodies, we might almost say all bodies, but some to a greater degree than others, and by reacting on the carbon allows a better or a worse contact to be made in the electric circuit, according as the temperature is raised or lowered. Not only is Edison's instrument sensitive to changes of temperature, but it also indicates the increase or decrease of moisture in the atmosphere. Mr. Edison, indeed, goes so far as to say that "spitting on the floor will be indicated by a movement of the balanced needle." Surely, the drawing rooms of our transatlantic friends ought to be furnished with one of these instruments in a neat case, with a recording apparatus, so that the number of expectorations in the room might be daily registered. We do not like the record of our sins to glare upon us too strongly, and are apt to say "out of sight out of mind," but a gentle reminder of this sort might prove effective in reducing expectorative action to a minimum.

This wonderful instrument, however, is a very simple affair, after all. Everybody can make one. The most important parts of the apparatus are the battery and the galvanometer. In the electrical circuit we connect the galvanometer and some carbon buttons. The carbon is in contact with the wire-conductor of the circuit, or between two metal plates. The current passes through one plate, then through the carbon, and through the other plate to the opposite pole of the battery. Mr. Edison connects the plates by a piece of hard-rubber or gelatine, but it will at once be seen that the best material to connect the plates is a non-conductor which is exceedingly sensitive to heat or moisture. The instrument proper then requires carbon contacts, such that the expansion or contraction of a second substance under the influence of heat or moisture allows the carbon to make better or worse contact, and thus provides for an increased current by decreased resistance at the points of contact, or, on the contrary, increases the resistance and decreases the current. Mr. Edison's discovery is given as follows by the *New York Herald*:—"Mr. Edison next exhibited his new discovery, the thermopile, to measure infinitesimal degrees of heat. Mr. Edison explained the instrument to the *Herald* reporter in the following words:—'It consists of a carbon button placed between two metallic plates. A current of electricity is passed through one plate, then through the carbon and through the other plate. A piece of hard-rubber or of gelatine is so supported as to press against these plates. The whole is then placed in connection with a galvanometer and an electric battery. Heat causes the strip of hard-rubber to expand and press the plates closer together on the carbon, allows more current to pass through, and deflects the needle of the galvanometer. Cold decreases the pressure. Moisture near the strip of gelatine can be measured in the same way, by increasing or decreasing the pressure, and accordingly deflecting the needle. By means of this apparatus, or one combined with sensitive electrical galvanometers, it is possible to measure the millionth part of a degree Fahrenheit. Infinitesimal changes in the moisture of the atmosphere can be indicated in the same way—changes which are a hundred thousand times less in quantity than those that can be indicated by the present barometer. It will thus foretel a storm much more readily. The carbon button I have in this instrument is of lamp-black burned from rigolene.'"

We almost stand aghast at the statement of the results obtained with the aid of this instrument, which Mr. Edison has long been engaged in perfecting. Six months ago he was invited by Professor Langley, of Pittsburg, to adapt it for measuring the heat of stellar spectra. This he has succeeded in accomplishing, with such wonderful success that he is now able to measure the heat of even the telescopic stars. By focussing the heat rays of these distant bodies so as to concentrate them on the substance pressing on the carbon button, he is enabled to measure accurately their relative and actual heats. In this way it is not improbable that, in astronomical researches, the distance of the stars from the earth may be measured by their degrees of heat acting on the thermoscope. The condition of moisture can be determined by substituting a bar of gelatine for the hard-rubber used in the heat-measuring apparatus. Indeed, so sensitive to the influence of moisture is this delicate instrument, that a little water spilled on the ground in the same room with the instrument, or even, as we have previously mentioned, spitting on the floor, will be indicated by the movement of the balanced needle. A little piece of common paper was damped with the tongue and held in that condition fully an inch-and-a-half away from the gelatine bar pressing on the carbon button. The needle instantly responded to the influence by moving several degrees of a circle, returning again when the paper was withdrawn. Next month this new thermometer is to be tested for astronomical purposes. Professors Brackett and Young, of Princetown College, will go to California to observe the solar eclipse, and intend using Mr. Edison's instrument during their investigation.

CORRESPONDENCE.

THE MICROPHONE AND THE TELEPHONE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Allow me to make a few observations on the Microphone and Telephone, and the remarks thereon in the articles by Messrs. W. Smith and Seabroke in numbers two and three of your journal.

From a rough description of the Microphone, in a late number of the *Débats*, I constructed one, adopting an ordinary cigar box and the carbon from a used Leclanché. The vertical rod was a piece of ordinary hard lead-pencil. All the phenomena described in *The Electrician* and elsewhere are easily obtainable on a land-line two miles in length between my cable house and the town, and on which all my previous telephonic experiments had been made.

The battery power used varied from one to twenty Menotti's, with high internal resistance, and one to ten Leclanchés, with a very low resistance. I find the lower the battery power the better are the results, and with one Leclanché everything goes most successfully over the distance mentioned. The insertion of extra resistance in the circuit makes but a comparatively trifling difference in the results; my watch was clearly heard on this circuit with an interpolar resistance of 15,000 ohms, using four Leclanchés.

In the last paragraph of Mr. W. Smith's article I observe that he anticipates being able to converse through our longest cables. Now, whilst I find that resistance enters little or nothing into the question, a stumbling-block has yet to be overcome in the cable's electrostatic induction. Together with my colleague at Otranto, Mr. Eggington, we have had repeated trials both ways on this cable, 187 knots in length. No variation whatever in the battery power enables us to hear even mechanical sounds, the rapid current-waves from the microphone's vibrations being unable to sufficiently quickly discharge themselves through the telephone; in fact, the disc remains attracted the whole time the microphone is in circuit, and, by making and breaking "earth" contact at the receiving end, the sound appears the same, but stronger, than that from a Morse armature on short circuit*.

Our latest trials were with a positive current on the microphone, and a weaker negative one at the receiving end, but still without success, and certainly, unless we can devise a double-current microphone, cables are cut off from its field of operations. With Corfu, 150 miles, no better results are obtainable, and, for the present, all further trials have been suspended.

Mr. Seabroke very justly takes exception to the term "microphone." It does not do for sound what the microscope does for sight. To my idea it should be termed a "sound finder," seeing that sounds absolutely inaudible to the sharpest human ear become with it quite distinct; for instance, a hair drawn across the surface of the microphone can never be heard by the naked ear, yet through the microphone the noise of its passage is unmistakeable. Audible sounds are not magnified; a pistol fired over a microphone does not cause us to hear a salvo of artillery, nor does the ticking of a watch increase to the noise of a steam-engine.—Yours truly,

W. G. FORSTER.

Zante (Greece), June 19th, 1878.

* The telephone coil has not more than 25 ohms' resistance. Bearing in mind this principle, surely we might greatly modify our present system of electro-magnetic instrument coils.

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DISPUTED INVENTION OF THE MICROPHONE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As I happen to know that Mr. Preece is not in England, and as it is possible that no disclaimer can reach you in time for your next issue, I venture to ask your readers to suspend their judgment for the present upon the extraordinary rumours affecting his reputation which you have given publicity to. I do so without communicating with Mr. Preece, and without any knowledge of the circumstances beyond what may be gathered from your article, and what we all have heard when Mr. Preece has been describing Prof. Hughes's discovery. They are, however, conclusive enough for the object I have in view.

First, there can be no doubt as to the genuineness of Professor Hughes's discovery. You yourself describe it as an admirable product of inductive reasoning; and, as Professor Hughes has never pretended that he was the only person in the world who might be working out the same problem, there can be no accusation laid against him on that score. But, if it is an original and independent discovery—and everybody must own that it is so—what becomes of the implied accusation against Mr. Preece? Even if Mr. Edison had invented something nearly related to the microphone—which is not the fact—and Mr. Preece knew it, it is clear that he did not betray the confidence which Mr. Edison professes to have placed in him. Indeed, this affectation of trustful confidence is really too comical on the part of an astute American who has taken out some hundreds of patents for many useless as well as useful things. Would he have us believe that in this instance he made a great discovery, but in his modesty held it back for a "year or more," and indulged in confidences with a "stranger," instead of taking out his patent? But, after all, what had he to confide? We are wanting in details here. Judging, however, by his own words, it is a "thermopile," or "direct impact telephone," to neither description of which does Professor Hughes's contrivance bear but a very remote resemblance. No one who knows that gentleman would doubt his readiness to acknowledge indebtedness where it is due; and, as to Mr. Preece, he has been studiously careful to disavow any personal share in the several inventions which he has lately been called upon to make public. More than this, so far from overlooking Mr. Edison's pretensions, such as they are, that gentlemen has received his full deserts at Mr. Preece's hands. A report of one of Mr. Preece's lectures appears in *Nature* this week, and those who did not hear the discourse itself will now see that ample justice has all along been done to Mr. Edison, of whom Mr. Preece says, "No one has been nearer a great discovery. His telephone is based on the variation of resistance due to pressure. He used carbon and finely divided matter; but he worked on the idea that the difference in pressure was produced by the vibrations of a diaphragm." This apparently is what had been "confided" to Mr. Preece. But, as he very justly adds, "Had Mr. Edison thrown away his diaphragm he would have forestalled Professor Hughes in this respect, and found that the sonorous vibrations themselves would produce this difference of pressure." Anybody who understands the subject will readily appreciate the immense difference which this "throwing away of the diaphragm" involves.

There is nothing at once so little and yet so excusable as the squabbles about priority in matters of this kind, but they become a positive nuisance when one man sets himself up not only as the chief of inventors but the fountain of all ideas. Mr. Edison nearly invented the telephone, and, quite unintentionally, he had nearly discovered the microphone. It is vexing, no doubt, to be forestalled by Professor Bell on the one hand and Professor Hughes on the other; but it is evident Mr. Edison has neither been betrayed nor poached upon; for the microphone, at any rate, is a discovery which he was not even so much as seeking after.

25th June, 1878. J. LAISTER.

THE MICROPHONIC PROBLEM.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have read the original article under this heading, and "Alfred A Soward's" criticism thereon. As a question of chemistry, it may be interesting to know what "combustion" is, but, as the original article deals with phenomena which are conventionally so designated, and which even this writer admits do, "to a certain extent, go on," the character of the criticism is peculiarly unpractical.

What I beg most emphatically to protest against, however, as a practical electrician, is the notion that Professor Bell, or any one else desiring to be intelligible when addressing men of his own craft, should be required to borrow the roundabout phraseology of the Birkbeck Institution. If that institution has anything substantial to teach us, let us have it by all means, but we don't want irrelevant dissertations on side issues which have no bearing upon the real subject under discussion. F.

24th June, 1878.

TELEPHONE AND MICROPHONE.

The accompanying letter from Mr. T. A. Edison was published by the *New York Tribune* on the 8th of June. As will be seen, it was written in reference to an article which had previously appeared in that paper.

The letter contains one or two statements upon which we can speak authoritatively. Mr. Edison says, in the last paragraph but two, "The claim of Prof. Hughes," etc. Now, Prof. Hughes has never made any claim to be the discoverer of a heat-measurer. The writer, with two other gentlemen, was present one day to see and hear of Prof. Hughes's discovery, and Prof. Hughes then stated he had accidentally noticed the action of heat upon a quill tube used to replace a glass tube; and we have every reason to believe that Mr. W. H. Preece was entirely ignorant, for several days after, that such an effect had been noticed. Mr. Preece first heard of this when visiting Prof. Hughes with several other friends, and, according to our information, which seems conclusive, Mr. Preece *immediately* mentioned Mr. Edison's discovery as described in a newspaper report. The great similarity between the two was easily seen. Neither Prof. Hughes nor Mr. W. H. Preece have in any of their public descriptions claimed this discovery. True, it was mentioned in the discussion at the Society of Telegraph Engineers, but was not referred to in the original paper.

Mr. Edison speaks of Mr. Preece as being a "coadjutor" of Prof. Hughes, but this allegation, as will be seen from Mr. Preece's communication printed in another column, is emphatically denied:—

THE QUESTION OF PRIORITY OF INVENTION BETWEEN HIM AND PROFESSOR HUGHES, OF LONDON—MR. EDISON CLAIMS A VIOLATION OF HIS RIGHTS, AND A BREACH OF CONFIDENCE BETWEEN FRIENDS.

TO THE EDITOR OF THE TRIBUNE.

SIR: Allow me to make a few observations upon an editorial article which appeared in yesterday's *Tribune* upon the recent claims advanced by Professor D. E. Hughes, of London, to the invention of the leading features of my carbon telephone, and of my microtasimeter or instrument for the measurement of minute degrees of heat.

You have attributed to Professor Hughes two improvements upon my methods of preparing the carbon buttons for the telephone, namely, in the metallization of the carbon by plunging it in mercury, and in the division of the carbon into several pieces. Your supposition that the latter process is not identical with my use of gas-retort carbon is perfectly correct, but the subdivision of the carbon had been repeatedly tested by me in my experiments on the telephone, especially in a series conducted at the special request of President Orton shortly before his death, of which the illustrative drawings were seen at the time by several persons, and are still in my possession. The metallization of the carbon by plunging it in mercury is also a process perfectly familiar to me, having been employed in many of my telephone experiments of last year, and, though mercury is not specially named, it is clearly included in the expression "finely divided metals" which occurs in the memoranda I furnished Mr. Geo. B. Prescott for his forthcoming work on "The Speaking Telephone," as printed in *The Journal of the Telegraph* for the 16th of April last. Mr. Hughes seems to have been so impressed with this phrase that he employs it repeatedly, speaking of "mercury in a finely-divided state," of "holding the mercury in a fine state of division," of "metal distributed—in a fine state of division," of "iron in a fine state of division;" again, of "the minute division of the iron," and, lastly, of "a platinum surface in a finely divided state."

The change of electrical resistance with enormous rapidity by plumbago under pressure was a discovery of my own, distinctly set forth in my application for a patent for an "improvement in speaking telegraphs," dated July 20, 1877, as published at the time in *The Philadelphia Press* and *The Scientific American* (July 28, 1877). This discovery evidently covers the principle claimed as his own by Professor Hughes. He says: "It is quite evident that these effects are due to a difference of pressure at the different points of contact"—which is precisely the principle of my carbon telephone, thus set forth months ago by Mr. Geo. B. Prescott in the above-mentioned volume: "By constant experimenting, however, Mr. Edison at length made the discovery that, when properly prepared, carbon possessed the remarkable property of changing its resistance with pressure, and that the ratios of these changes, morever, corresponded exactly with the pressure."

You consider, as the most striking difference between my telephone and the instrument of Professor Hughes, that in the latter the diaphragm is dispensed with. In his own words:—"It will be seen, however, that in the experiments made by myself, the

diaphragm has been altogether discarded, resting as it does upon the changes produced by molecular action, and that the variations in the strengths of the curents flowing are produced simply and solely by the direct effect of the sonorous vibrations."

The following extract from Mr. Prescott's book, as given in *The Journal of the Telegraph*, April 16, 1878, will show that the discarding of the diaphragm is my own invention:—

"In the latest form of transmitter which Mr. Edison has introduced, the vibrating diaphragm is done away with altogether, it having been found that much better results are obtained when a rigid plate of metal is substituted in its place. With the old vibrating diaphragm the articulation produced in the receiver is more or less muffled, owing to slight changes which the vibrating disk occasions in the pressure, and which, probably, results from tardy dampening of the vibrations after having been once started. In the new arrangement, however, the articulation is so clear and exceedingly well rendered, that a whisper even may readily be transmitted and understood. *The inflexible plate*, of course, merely serves, in consequence of its comparatively large area, to concentrate a considerable portion of the sonorous waves upon the small carbon disk or button; a much greater degree of pressure for any given effort on the part of the speaker is thus brought to bear on the disk *than could be obtained if only its small surface alone were used.*"

The claim of Professor Hughes to the discovery that a modification of his microphone can be used as a measure of minute degrees of heat is still more preposterous than the preceding. This is a discovery of mine, which was first announced in the *Washington Star* of the 19th of April last. A copy of that paper was sent by me to Mr. W. H. Preece, the coadjutor of Professor Hughes in this pretended "invention," and I have positive evidence that it reached him before the presentation of the so-called "microphone" to the Royal Society, inasmuch as he has made an extract from it in his address of May before the London Society of Arts.

Mr. W. H. Preece, electrician to the London Post Office Department, was in this country in the early part of last year, and visited my laboratory. I freely showed him the experiments I was then making, including the principle of the carbon telephone and the variability of conducting power in many substances under pressure. I made him my agent for the presentation of this telephone, and subsequently of the phonograph, in England, and kept him informed, by copies of publications and by private letters, of my leading experiments, as he always manifested a great desire to be the means of presenting my discoveries to the British public.

I, therefore, regard the conduct of Mr. Preece in this matter as not merely a violation of my rights as an inventor, but as a gross infringement of the confidence obtained under the guise of friendship.—Yours very truly, THOMAS A. EDISON.

Menlo Park, N. J., June 6, 1878.

THE PHYSICAL SOCIETY.

On Saturday, the 22nd instant, a meeting of the Physical Society was held at the Science School, South Kensington, under the presidency of Professor W. G. Adams, F.R.S.

After the usual formal business had been disposed of,

Professor SYLVANUS P. THOMPSON exhibited a series of Magnetic Figures, illustrating Electrodynamic Relations. In the course of his explanatory remarks, he observed that the lines of magnetic force around a wire carrying an electric current can be shown by passing a wire through a glass plate, strewing iron filings around, and tapping the plate gently. The filings may be fixed in their places, if the plate has previously been gummed and dried, by softening the gum with steam. Such a prepared plate may be used to project the figure of the magnetic curves in the lantern. Two parallel-like currents attract, their curves forming a figure illustrative of the action; or they repel if travelling in opposite directions, the repulsion being evident from the form of the curves. It was shewn in the remaining numbers of the series that, in a similar way, a very large number of electrodynamic relations could be illustrated by curves produced in a similar manner. Figures were thrown upon the screen, illustrating the law of oblique currents, the attraction of a magnet into or its repulsion out of a circuit, the deflection of a magnetic needle by a current, and the mutual tendency to rotation of a current and a magnet pole. A very curious figure was produced by a current running through a magnet longitudinally. A transverse section of the lines of force at a pole gave neither the radical lines of the magnet nor the circular lines of the current, but a series of spirals. It was argued that Faraday's conception of the lines of force tending to shorten themselves supplied the means of interpreting the physical effects indicated by the lines of force in the various figures.

During the course of the meeting, the President intimated that, in addition to the papers fixed to come on, there were a modified form of Professor Hughes's microphone, by N. Haddow, and a combination of the phoneidoscope and telephone, by Mr. Tisley.

Owing, however, to the number of papers before the meeting, neither of these was described. Sir Frederick Elliott also withdrew his paper on "Equipotential Surfaces of a Conductor under Influence."

The PRESIDENT, at the close of the meeting, intimated that that was the end of the Session, and adjourned till November.

LIGHTING BY MEANS OF ELECTRICITY.

M. HIPPOLYTE FONTAINE, at the recent meeting of the Institution of Mechanical Engineers, at Paris, read a paper under the above title. He stated that the light obtained by means of an electric current, of which the practical application, not long since, was confined to lighthouses, has definitely taken its place for industrial purposes, since the invention of the Gramme machine with continuous currents. This light is now regularly employed in mechanical workshops, cloth factories, spinning mills, dye works, sugar works, railway stations, &c., &c. The number of industrial applications, which was 4 in 1874, and 12 in 1875, was raised to 85 in 1876, and to 350 in 1877, whilst at present there are upwards of 500 applications of the light, amounting in intensity to more than a million-and-a-half of candles. This is not much, compared with the total of illumination, public and private; but it is a great deal when it is considered how recently the new light made its first appearance, and how many difficulties there are to be overcome in the introduction of new inventions. The electric light does not interfere with gas light, nor with oil light, nor with candle light. It will not revolutionise, as has often been averred, the question of lighting, destroying what is now in use, and monopolising every industrial application, domestic and public. The electric light has its place marked out for it under many circumstances; but, far from diminishing the consumption of the other lights, it will lead to their further development, by demonstrating the advantages of a more powerful and more complete illumination. Frequently inferior in point of economy to the other systems, it possesses special qualities of its own, by which it is adapted, as a space-penetrating light, for the solution of problems heretofore unsolved. With the aid of a lenticular projector it acquires a prodigious power of reaching into space, and distinguishing objects several miles distant. By the naked light, unaided, spacious halls or extensive yards may be lighted up, so that, by night as by day, the movements of merchandise, or manufacturing operations on a large scale, or work in open air, may be followed up. By the interposition of ground glass a softened and uniform light is produced, which is very advantageous for many manufactures. The Gramme machine, with its continuous currents, is distinguished from the machine with alternative currents, with which a great degree of success has been attained during the past few months. The former is simple, powerful, and very compact, contains no delicate organs liable to alteration, can be erected in the course of a few hours without foundations, and can be worked for months without interruption or inconvenience. The type of the machine used for industrial purposes is of the following dimensions:—Total length, 21·6 inches; width, 14·75 inches; height, 21·6; volume, 4 cubic feet; diameter of the bobbin, 7 inches; number of revolutions per minute, 850; weight of the copper in action, 70lbs.; total weight, 397lbs.; power necessary for driving the machine, 2½ horse-power. As to the illuminating power, if the regulator and photometer be placed in the same horizontal line, and the axes of the two carbons in the same vertical line, a light equal to 2,400 candles is produced. If the regulator be suspended at a height of 16·4 feet, and the measure be taken below at 16·4 feet from the foot of the regulator, the upper carbon acts as a reflector, and 8,400 candles are indicated by the photometer. Again, if the measure be taken as in the first case—the photometer and the regulator at the same level—whilst the lower carbon is fixed a little in advance of the upper carbon, so as to create a dazzling screen behind it, then 6400 candles are obtained. The power, 2½ horse-power, is constant in the three cases. In order to illustrate by a practical example the secondary position of the moving power as an element of the total cost, the author of the paper stated that MM. Heilmann, Ducommun, and Steinlen, the well-known manufacturers of machine tools at Mulhouse, who had had their foundry lighted up by means of four Gramme machines during the last four years, found the total cost of lighting per hour as follows:—Carbon, from gas retorts, 8·36d.; steam consumed, 3·42d.; superintendence, 2·85d.; interest and depreciation, 48·45d.; total, 63·08d., or a fraction over 5s. 3d. The moving power in this instance, then, only amounts to a twentieth of the whole cost, whilst the charge for interest and depreciation, which are so much the less as the machines are less costly and last the longer, amounts to three-fourths of the total expense. A machine, which may be seen at the Exhibition, yields three times more light for equal quantities of matter in action and power used than any of those which have yet been tried in England, France, or anywhere else. This machine weighs 441 pounds, costs £60, and yields a light equal to 30,000 candles. Notwithstanding the low price and the excellence of the performance, this machine cannot be recommended for use, as the elements requisite for durability are wanting. But of the Gramme machine—the normal type of the workshops—it may be affirmed that several hundreds of them have been at work during the whole winter, some without interruption for underground operations, without costing a farthing for repair or maintenance, except for lubrication. It may also be affirmed that, in the workshop of MM. Sautter and Lemonnier, on the canal from the Marne to the Rhine at Sermaize, and in the foundry of M. Ducommun, these machines have actually been at work for four years, without giving the slightest trouble. MM. Heilmann, Ducommun, and Steinlen, of whose machine some particulars have just been given, calculate that, if their foundry had been lighted by gas equal to the light supplied by the electric machine in their establishment, the cost would have been double the expense mentioned. M. Ernest Manchon, proprietor of a cloth factory at Rouen, has lighted by electricity one of his sheds, formerly lighted by gas. The means are thus afforded for making a complete comparison of the two systems. The shed in question is rectangular; it is 16¼ feet high, 79¼ feet wide, and 138 feet long, covering an area of 10,971 square feet. It contains 160 looms, which had been very imperfectly lighted by 160 large gas burners, by each of which 5¼ cubic feet of gas was consumed per hour. These 160 burners have been replaced by six Gramme machines and six regulators, from which the light is projected on the roof, yielding a uniform light all over the shed, which is entirely satisfactory. Before the introduction of the new light the joists stood out from the ceiling; but M. Manchon, without hesitation, incurred the expense of a new ceiling, on which he may now congratulate himself. After five months' working with the new method of lighting, the following are the results of M. Manchon's calculations, showing the pecuniary benefit which he has derived from it. First cost: roof carpentry, £156 10s.; roof painting, £49 19s. 2½d.; roof making carpenters' benches, £5; roof wood, £2 6s.; cost of five stoves, £5 12s.; cloth for the same, £1 8s.; enclosure

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for the machines, carpentry and glazing, £8 9s. 6½d.; enclosure for the machines, zinc covering for the floor, 12s. 7½d.; six Gramme machines, six regulators, and conductor, £560; shafting, £37 17s.; driving belts, for transmitting the power 680 feet, for the machines, 230½ feet, £29 8s. 9½d.; framing for the shafting, £3 4s. 2½d.; carriage and sundry expenses, £4—total, £882 3s. 4d. The working cost of the electric light was as follows:—Interest 6 per cent., depreciation 6 per cent., on £882 3s. 4d. per year, 660 hours, £105 9s. 9½d., or 3s. 3½d. per hour; driving power, hire, £30 per year, or 10½d. per hour; carbons, 27in. per hour, at 6·53d. per ft., waste included, £40 14s. 8½d. per annum, or 1s. 2½d. per hour; superintendence and maintenance of the machines, £13 4s. per annum, or 4½d. per hour; lubricating oil, £1 13s. 7½d. per annum, or ½d. per hour—total per annum, £186 2s. 1½d., or 5s. 10½d. per hour. What was the cost of lighting by gas? The original price of 160 burners, at £1 11s. 8d. was £253 6s. 8d. The interest and depreciation on this, at 12 per cent., was £30 14s. 5d. per annum, or 11d. per hour; the consumption of gas at 7s. 2½d. per 1,000 cubic feet, £209 10s. 8½d., or 6s. 3½d. per hour; repairs and maintenance of the fittings, £8 per annum, or 2½d. per hour; glass £4 per annum, 1½d. per hour—total, £252 5s. 1½d. per annum, or 7s. 6½d. per hour. The annual saving by electricity was, therefore, £57 3s.; per hour 1s. 8½d., or 22·6 per cent. The workmen are very well pleased with the light, which enables them to see the most delicate shades of colour, and prevents them falling into errors formerly experienced in the renewals of broken threads.

RECENT PATENTS.

3936. Distributing and Increasing with Atmospheric Electricity Currents proceeding from a Single Source of Electricity for Supplying several Lighting Centres, *P. Jablochkoff.—Dated October 17, 1877.* 4d.

This invention has for its object to effect the distribution of electric currents proceeding from a single source of electricity for the purpose of supplying at one time a number of illuminating apparatus, and at the same time to strengthen such currents by means of atmospheric electricity. In order to obtain useful results from a current proceeding from a source of dynamic electricity; instead of operating directly with the said currents as heretofore, the currents are caused to undergo a double transformation by firstly converting the dynamic electricity into statical electricity, and then reconverting this into dynamic electricity, and it is by means of the latter current that the useful results are obtained. For the above purpose, instead of closing the circuit of a source of electricity by means of a continuous conductor as heretofore, the conductor coming from one of the poles of the electrical source is united with one of the armatures of a condenser, composed of one or more Leyden jars of large surface, or of special construction.

4053. Electro-Metallurgical Apparatus, *F. Conradi. (A communication.)—Dated Nov. 1, 1877.* 4d.

This invention relates to a new proceeding to produce pure metals, alloys, combinations, salts, haloids, by application of the electrolytic method on impure metals, alloys, combinations with sulphur, arsen. chlor., &c., cement metals, intermediate products, ores, rubbish, and scrap, by making use of magneto-electric or electro-dynamic machines; further, of constant baths and anodes free from polarization, in some cases by making use of conical or rotating anodes or catodes, or by intercalating intermediate metals or other substances. Polarization is avoided by making use of anodes, which are dissolved under the influence of the current; hereby, polarization is best avoided. Combinations, by which the current is not conducted, as, for instance, metal salts, are dissolved in water, acids, alkalies, or salts, the anode being formed in this case by platinum, or, if this should be too expensive, by plastic coal, prepared in flat plates or conical figures, the latter being moved by rotation; hereby, the gas bubbles, by which polarization would be generated, are removed, and a much larger surface of anodes generated. If, at last, polarization increases, the anode is changed and replaced after being cleaned. The catode is formed by plastic coal or metal similar to that which is precipitated, or by the metal which is to be alloyed with the same.

4059. Circuit Closers for Electric Alarms, *Bristow Hunt.—Dated November 1. 1877. (A Communication.)* 6d.

In a circuit closing device suitable for application to a doorway, a number of wooden slats are suitably secured to a mat made of rubber, oilcloth, carpet, or other suitable flexible material, and to these slats (preferably to each alternate one) are secured a number of short elliptic metal springs, which are fastened at one end only so as to yield under pressure, two metal pins being secured in the slat adjacent to the curved portion of each spring plate. One of these pins is connected to one wire of an electric alarm, and the other pin is connected to the other wire thereof, so that when any spring plate is brought in contact with the pins the electric circuit will be complete and the alarm will be given.

TELEGRAPH SHARE LIST.

Amount of Issue.	Amount of Share.	Paid on Share.	Company.	Reserve as per last Report.	Dividends calculated at rate per cent. per annum. 1875. %	1875. %	1876. %	1876. %	1877. %	1877. %	When Payable.	Prices. 1875. Highest.	1875. Lowest.	1876. Highest.	1876. Lowest.	1877. Highest.	1877. Lowest.
£3,254,580	Stock	100	Anglo-American	Deferred receiving no dividend until 6 per cent. has been paid to Preferred.		year.	5	4†	3	5	† Div. 5 % per ann. for quarter ending Dec. 31, 1876, 2 % for quarter ending Mar. 31, 4 % for quarters ending June 30 and Sept. 30, 6 % for quarter ending Dec. 31, 1877, and 4 % for quarter ending March 31, 1878.	75¾	51½	68½	53	62¾	52
1,872,710	Stock	100	Do. Preferred B		—	—	10	2	6	6		Crtd	1876.	93	75	88½	79
1,872,710	Stock	100	Do. Deferred A		—	—	Nil.	6	Nil.	4		Crtd	1876.	44	29	38	25½
1,300,000	10	All	Brazilian Submarine	120,000	5	5	5	5	5	5	Quarterly.	7¾	6	7½	5¾	6¾	5⅞
160,000	10	All	Cuba (Limited)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60,000	10	All	Do. 10 per cent. Preference	—	—	—	—	—	—	—	—	—	—	—	—	—	—
116,379	10	9	Direct Spanish (Limited)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
58,430	10	All	Do. 10 per cent. Preference	—	—	—	—	—	—	—	—	—	—	—	—	—	—
65,000	20	All	Direct United States	Nil.	—	Nil.	Nil.	Nil.	Nil.	5	Quarterly.	13	7	11½	6¼	13¾	9½
369,700	10	All	Eastern (Limited)	110,000	5	year.	5	5	5		*a*Jany., April, July, Oct.	8	6⅝	7⅛	5	8¼	6⅝
232,000	100	All	Eastern 6 per cent. Debentures	—	—	—	—	—	—	—	—	—	—	—	—	—	—
200,000	100	All	Do. 5 per cent. Debentures	—	—	—	—	—	—	—	—	—	—	—	—	—	—
700,000	10	All	Do. 6 per cent. Preference	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,997,500	10	All	Eastn. Exten. Australasia & China	125,404	5½	year.	5	year.	5	year.	*a*Jany., April, July, Oct.	8¼	7	7½	5½	8	6¾
320,000	100	All	Eastn. Exten. 6 p.c. Deben. (1875)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
192,680	10	All	German Un. Tl. and Tst.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,500,000	10	All	Globe Telegraph and Trust	Nil.	5	7 4-5	4½	7 5-6	3½	7 6-7	*b*Jany., April, July, Oct.	6¾	5¼	5⅝	4¾	5¼	4¾
1,500,000	10	All	Do. 6 per cent. Preference		6	6	6	6	6	6	Jany., April, July, Oct.	10½	9¾	10¼	9¼	10½	9¼
150,000	10	All	Great Northern	85,543	5⅝	year.	6⅞	year.	6⅞	year.	5 % intrm. Jan. 1, July 1. Final Dividend April.	11½	7¼	9⅝	7	8	7
			Shares to Bearer, or can be Regstrd.														
—	25	All	Indo-European	—	—	—	—	—	—	—	—	—	—	—	—	—	—
120,000	10	All	Mediterranean Extension (Lmtd.)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
32,000	10	All	Do. 8 per cent. Preference	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	18	All	Reuter's (Limited)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
65,000	10	All	West India and Panama	16,000	Nil.	Nil.	Nil.	Nil.	1	1	‡ Converted from a 10 %	4⅝	1⅝	2½	⅝	3⅝	1⅝
34,563	10	All	Do. 6 per cent. Preference		7/6ac	year.	10/ac	year.	6‡	6	into a 6 % 1st Preference.	12	9	11	7	11	7½
67,500	20	All	Western and Brazilian	7,793	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Half-yearly.	18¼	9½	10⅞	4½	5⅞	4½
$1,500,000	$1000	All	Western Union Telegraph 7 per cent. First Mortgage Bonds	—	7	7	7	7	7	7	May, November.	108	102½	109¼	105	113	104
£1,030,000	200	All	Do. 6 per cent. Sterling Bonds	Redeemable by annual drawings at par.	6	6	6	6	6	6	March 1, September 1.	93	86	98	89	101	94

a Year ends March 31st. Interim Dividend of 5 per cent. Final dividend in July. *b* Year ends July 19th. Final dividend in July.

Companies.	Business Done. Th., 20.	F., 21.	Sat., 22.	Mon., 24.	Tu., 25.	Wed., 26.
Anglo-American (Lim.)	63¾, ½	63¾, 4⅛	—	63⅜, 4½, 4	64⅛, ½	—
Do. Preferred	88¾	88¼	89	88¼	88¾	88¼, ½
Do. Deferred	36½, 36	36	36	36¾, ½, 7, ½	37⅛, ¼, ½	37⅛, ½
Brazilian Submarine	7⅞	—	—	—	7⅞, 7	—
Cuba (Limited)	—	9⅞	9⅞	9⅞, ½	9⅞, ½, 11-16	—
Drct. U. S. Cable (Lim.)	14⅜	14⅜	14⅜, ½	14⅜, ½	14⅜, ½, ⅜	—
Eastern (Limited)	7⅞, ½	7 9-16, ½	7 9-16, ½	7 11-16	7⅞, ½	7⅞, 11-16
Do. 6 pr. cnt. Deben.	103½, 7½, 8½	—	—	103½	—	—
Do. 6 p. c. Prefrnce.	—	11⅜	11⅜, ½	—	—	11⅜, ½
Eastern Extension, Austral., & China (Lim.)	7⅞, ½	7⅞	—	—	7⅞	—
Do. 6 p. c. Prefrnce.	110	—	—	—	—	—

Companies.	Business Done. Th., 20.	F., 21.	Sat., 22.	Mon., 24.	Tu., 25.	Wed., 26.
Globe Tl. & Tst. (Lim.)	7 7-16	5 7-16	5 7-16	5½	—	—
Do. 6 p. c. Prefrnce.	11	11½, 11	11⅜	11	—	10⅞
Great Northern	9 3-16	—	9 1-16, ½	9⅞, 5-16	9⅞	—
Indo-European	—	—	19½	—	—	—
Mediterran. 8 p. c. Pref.	9⅞	—	—	—	—	—
Submarine	—	222	—	—	—	—
Do. Scrip	—	—	—	—	2 1-16	—
W. India & Pan. (Lim.)	—	2 9-16	—	—	2½	—
Do. 6 p. c. 1st Prefnc.	9	9 15-16, ½	9⅞	—	9⅞, 9	—
Do. 2nd Preference	—	—	—	—	3⅞	—
*Western and Brazilian (Limited)	—	—	5⅞	—	—	—

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NOTES.

A New Cable.—The Eastern Telegraph Company has commenced laying a cable from Tenedos to Kemer.

The Microphone.—Professor Hughes's paper, read before the Physical Society, on June 8th, is published in the current number of the *Philosophical Magazine.*

The Use of the Telegraph in War.—It will be interesting to military men to know that the history of the use of the telegraph in the Civil War in America is being written by a gentleman (Mr. W. R. Plum) who possesses exceptional advantages for writing such a work.

A Single-fluid Atmospheric-depolarisation Battery.—A battery, which is exciting great interest in certain scientific circles, is shown at the Paris Exhibition by Mr. J. L. Pulvermacher. The positive element is amalgamated zinc, contained within a porous cylinder, the negative is silver wire, spun helically in the form of a hollow cylinder of very small diameter, and afterwards wound helically around the *outside* of the porous vessel, which is freely exposed to the air. The electrolyte is dilute sulphuric acid. We are assured that this couple, which has an electromotive force superior to that of a Daniell cell, is much superior to the Leclanché in point of constancy, even on short circuit. If this be the case, we shall doubtless have occasion to revert to what may be a very important invention.

At Sea in a Storm.—Captain O'Callaghan, of the ship *Yorkshire*, which arrived at the port of Melbourne from London on the 27th April, reports that when in lat. 30deg. 20min. S., long. 19deg. 30min. W. (about the meridian of Tristan D'Acunha), a heavy thunderstorm was experienced, with a perfect deluge of rain. The lightning was seen all round the ship in various shapes. What appeared to be large drops of liquid fire were seen falling down by the foremast and in front of the foresail among the sailors who were on the forecastle taking in the studding sail, but none of the men were hurt. After the storm Captain O'Callaghan went aloft, and upon examination found that the edge of the iron-band round the royal-yard, to which the chain halyards were secured, had been completely fused, while the ends of the iron jackstay along the yard, to which the sail is secured, were also fused, and a groove had been cut along the iron as if it had been done with a gouge. The top and ends of the yard were blackened, while underneath the yard there was a deposit of a yellow substance like sulphur.

Prof. J. G. McKendrick contributes to *Nature* the five following laboratory notes:—

The Phonograph as a Transmitter.—By placing Hughes's microphone on the disc of the phonograph the latter will transmit the sounds recorded on the tinfoil to a telephone at a distance. Thus we have a combination of microphone, phonograph, and telephone, which promises to be of use. It is very suggestive to hear the phonograph speaking in one room and to know that some one else, in another room or at a long distance off, is also hearing a repetition of the sound. I have no doubt that arrangements might be made by which the sound might be reproduced in a dozen different places at once.

The Working of the Phonograph.—After a good deal of experience I have come to the conclusion that a thin and slightly elastic membrane is the most suitable for loudness, whilst a rigid non-elastic membrane is most adapted for distinctness. From a consideration of the histological structure of the drum of the ear this is what one would expect. After the impressions have been made on the tinfoil, distinct speech, in a feeble voice, of most peculiar quality, like what one would imagine to be the tones of the fairies of old, can be heard from one of Marey's tambours, by bringing the point of the lever on the surface of the phonographic cylinder. With this method there is almost no friction, and consequently the marks on the tin-foil are not quickly rubbed out. By connecting a tube with the tambour and carrying it from the tambour to the ear, sounds may be heard, even as speech, after the marks have been so erased from the tinfoil as to be scarcely perceptible to the eye. Thus the tambour, when so used, may be said to be a microphone.

The Microphone.—I have tried many experiments with the ingenious arrangement of Mr. Hughes, and have been much impressed with its extreme sensitiveness. It may be used to make and break at pleasure the primary coil of the induction machine. When fixed to the box of a monochord the slightest touch of the wire with a camel-hair pencil sounds loudly in the distant telephone. When placed on the sounding-board of a piano I have heard distinctly a complicated piece of music eighty yards away; when attached to the throat by an india-rubber band, the faintest trill or whisper is audible; and it transmits the muscular sound from a powerful biceps.

A Lecture Experiment.—Place the heart of a frog on the electrodes of Dubois Reymond in connection with a sensitive reflecting galvanometer. The rhythm of the pulsations may then be observed by the swinging to and fro of the spot of light on a transparent screen. This has often been observed by physiologists, but, considered as a lecture experiment, it is very instructive.

The Sensibility of the Telephone to Feeble Currents.—As an example of this, I may instance the following experiment:—The gastrocnemius muscle of a frog was placed on the non-polarisable electrodes of Dubois Reymond, so that the transverse section touched the one electrode, and the longitudinal surface the other; the current thus obtained, when sent through a reflecting galvanometer, was sufficient to drive the spot of light from end to end of the scale, placed about three feet in front of the galvanometer; the galvanometer was then disconnected, and a telephone placed in circuit; it was then found that, on making and breaking the current, a faint but sharp click of the telephone plate was heard. No click could be heard when the muscle was removed and the two electrodes were connected with a bit of moist blotting paper. The muscle current was, therefore, sufficient to act on the telephone. The click was stronger when the muscle was placed in contact with two platinum terminals, and when a small carbon microphone was also placed in circuit. I then tried to ascertain whether any effect on the click could be produced by throwing the muscle into a state of tetanus, and I found that in these circumstances no click could be heard at all. In other words, during the state of muscular contraction the muscle current was so diminished (the *negative variation* so called) as to be unable so to affect the telephone as to produce audible sounds. The telephone thus was used instead of the galvanometer in a physiological experiment.

An Electrical Gyroscope.—According to an American contemporary, Mr. G. M. Hopkins has applied electricity to render the movement of the gyroscope as nearly continuous as possible. The gyroscope is fitted with a weighted base-piece, from which projects a pointed standard that supports the moving parts of the instrument. The frame, of which the

electro-magnets form a part, has an arm, in which is fastened an insulated cup that rests upon the point of the standard. One terminal of the magnet coil is connected with this cup, and the other terminal is connected with the bar that connects the cores of the two magnets. Upon the top of the magnet bar a current-breaking spring is supported by a hard rubber insulator, and is arranged to touch a small cylinder on the wheel spindle twice during each revolution of the wheel. The wheel, whose plane of rotation is at right angles with the magnet cores, carries a soft-iron armature, which turns very near the face of the magnet but does not touch it. The armature is arranged in such relation to the contact surface of the current-breaking cylinder that twice during each revolution, as the armature nears the magnet cores, it is attracted, but immediately the armature comes directly opposite the face of the magnet cores, the current is broken, and the acquired momentum is sufficient to carry the wheel forward until the armature is again within the influence of the magnet. The current-breaking spring is connected with a fine copper wire, that extends backward as far as the pointed standard, and is coiled several times to render is very flexible, and is finally bent downward so as to dip in mercury contained in an annular vulcanite cup placed on the pointed standard near the base-piece. The base-piece is provided with two binding posts for receiving the battery wires. One of the binding posts is connected with the pointed standard, and the other communicates by a small wire with the mercury in the vulcanite cup. The magnets and wheel, and all of the connected parts, are free to move in any direction on the point of the standard. When two large or four small Bunsen cells are connected with the gyroscope, the wheel revolves with enormous velocity, and upon letting go of the magnets (an operation that requires some dexterity), the wheel sustains not only itself, but also the magnets and other parts between it and the point of the standard, in opposition to gravity. The wheel, besides rotating rapidly on its axis, sets up a slow rotation about the pointed standard in the direction in which the *under side* of the wheel is moving. By attaching an arm and counter balance, so as to exactly balance the wheel and magnets on the pointed standard, the whole remains stationary. By *overbalancing* the wheel and magnets, the rotation of the apparatus around the standard is in an opposite direction, or in the direction in which the *top* of the wheel is turning. This gyroscope illustrates the persistency of a rotating body in maintaining its plane of rotation against the force of gravitation. It also exhibits the result of the combined action of two forces tending to produce rotations about two separate axes lying in the same plane. The rotation of the wheel upon its axis, produced in this instance by the electro-magnet, and the tendency of the wheel to fall, or rotate in a vertical plane parallel with its axis, result in the rotation of the entire instrument upon a new axis, which is coincident with the pointed standard.

CRYSTALLINE SELENIUM.—Mr. R. Sabine, in the June number of the *Phil. Mag.*, fully describes a series of electrical experiments with crystalline selenium. After describing the methods he employed for inserting the platinum wires, he points out that it is necessary to discriminate between the resistance of the selenium and the resistance of the junctions. The resistance of the junctions was found to be very various, but did not depend upon the manner in which the wires were imbedded in the selenium. The conducting power of the selenium was found to differ materially in different parts of the same plate, and the resistances of junctions and selenium were both affected by variations of temperature in nearly an equal ratio. Mr. Sabine experimented on the change of current strength when the current was reversed, but the majority of specimens did not alter sufficiently to afford definite evidence; and those recently prepared specimens which showed a considerable change generally gave unsteady readings. Careful investigation seems to point to the junctions, and not to the selenium, as the seat of this change. Professor W. G. Adams has pointed out that on increasing the battery power the apparent resistance of the selenium is diminished. Mr. Sabine states that, while the current was weak in some specimens, up to a certain limit, the resistance *increased* in one direction and *decreased* in the other direction, but after passing the limit in question the resistance *decreased* in both directions for any further increase of current, and supposes this result to be either a consequence of the operation of a Peltier effect or of electrolytic polarisation. He continues: "When the current passes through the selenium, it encounters a compound conductor analogous to that in which Peltier observed the cooling and heating effects of the junctions between antimony and bismuth. The crystals round the point of contact which cools contract, and have a tendency therefore to recede and to make the contact with their neighbours still worse; the crystals about the heated contact expand and improve the conduction. The effects are opposite, but not necessarily equal, because one junction may be more susceptible than the other. It is, of course, questionable how far this heating and cooling of an uncertain number of points of bad contact between the crystals of a seleniuum plate near the electrode would be sufficient to produce a sensible effect. But it is necessary to bear in mind the nature of the doubtful contacts which we are probably dealing with, and which the smallest conceivable approach or recession may improve immensely or break entirely. The supposition that the behaviour is due to polarisation is the more probable. The increase of the resistance with increasing current (when weak) in one direction indicates the existence in the selenium of a small independent electromotive force, and leads to the suspicion that a portion of the material in contact with one of the platinum electrodes is in an electrolytic condition, or both perhaps, one being more so than the other. As the measuring current increases in strength, it appears to polarise the electrodes in the selenium, as in an ordinary electrolytic conductor, and the small independent current is overpowered and lost sight of. The apparent decrement of resistance by increasing the battery is probably due to the fact that the polarisation increases in a less ratio than the measuring current, so that when this current is weak the polarisation is proportionally stronger, and the apparent resistance higher than when the measuring current is strong. The discharge after removing the battery is such as would answer to the depolarisation of an electrolyte. The experiments of Mr. Sabine on the action of light on selenium lead him to conclude that it is a surface action. He made up a plate in the form of a galvanic element, so that the surface alone might come under experiment. A platinum wire was fused into it by which it was suspended in a test-tube. The back of the plate and the wire near it were insulated with a coat of varnish. The apparatus was placed in a light-tight box, in which a shutter could be open to admit light on the uncovered face. Platinum foil was the opposing surface, and in the dark the E.M.F. of the element was 0·112 volt., the selenium being positive to the platinum. On admitting diffused day-light the selenium became negative to the Pt., with an E.M.F of ·056 volt. The paper also shows that the action of heat is identical with that of light.

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THE TELEPHONE.

[CONCLUDED FROM P. 64.]

BY BROWN AYRES.

The second class of articulating telephones consists of those which operate by a variation in the strength of a voltaic current. The strength of a current is, by Ohm's law,

$$I = \frac{E}{R};$$

nence any variation in I must be caused by a variation in either E or R. We know of no method by which the electromotive force of a battery can be varied continuously; and since a discontinuous variation could hardly be made so gradual as to produce waves in the current capable of carrying the more delicate shades of quality, we are forced, for the present, to regard that telephone which varies the electromotive force to be possible only in theory. The voltaic telephones, then, reduce to one class—those which vary the resistance of the circuit. A type of this form is what has been called the "Hydro-electric Telephone," described by Professor Bell, in his paper read before the American Academy of Arts and Sciences, in May, 1876. This consists of a membrane, to which is attached a platinum wire dipping into water or other highly resisting liquid. The motion of the plate to and fro causes the wire to be more or less submerged in the liquid, and hence the resistance between it and a wire projecting upward from the bottom of the containing vessel is varied. If v be the resistance of the liquid between the extremities of the wires, R the external resistance, and E the electromotive force in circuit, then

$$I = \frac{E}{R + v}.$$

Let the plate vibrate so that the extreme values of the resistances of the liquid are v_1 and v_2, then

$$\Delta I = \frac{E}{R + v_1} - \frac{E}{R \times v_2} = \frac{E\,(v_1 - v_2)}{R^2 + R\,(v_1 + v_2) + v_1\,v_2}$$

Now if R is small, compared with v, we may, to reach an approximate solution, neglect R; then

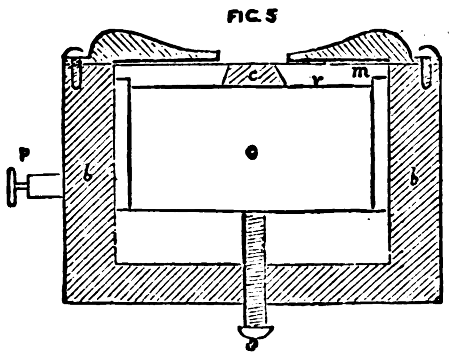
$$\Delta I = E\left(\frac{1}{v_1} - \frac{1}{v_2}\right) \quad . \quad . \quad . \quad . \quad (9)$$

or the variation in current strength, for that amplitude of vibration will be proportional to the variation in conductivity of the circuit. To reach this result we have been forced to consider R = O. But this can never be the case in a practicable arrangement; but the smaller is the internal resistance of the battery and conducting wires, and the larger the value of v_1, the nearer will the instrument approach to theoretical exactness.

In the form of instrument devised by Mr. T. A. Edison, where advantage is taken of his discovery of the variation, in resistance, of graphite or lampblack under pressure, the current is passed through the primary of an induction coil, while the secondary goes to line, and the current induced by variation in strength of the primary is utilised for actual transmission to line. If the resistance of the plumbago varies inversely as the pressure, then this instrument has the same difficulty to contend with as the "Hydro-Electric Telephone," and in the same degree.

The third class is represented, at present, so far as I know, by one instrument, the "Electrostatic Telephone," of the writer, Fig. 3).*

FIG. 5



This consists simply of an insulating box of wood or rubber, b, in which is placed a small condenser, c, the sides of which are connected by binding post, p_1, p_2. This condenser is constructed of tinfoil, as usual, insulated by discs of thin sheet rubber, such as is used by dentists. On either side of the condenser is placed a thin piece of vulcanite, v, v_1, the upper one of which is attached to a piece of cork, c, which bears against the ferrotype or mica plate, m, while the lower rests on a screw, s, by means of which the instrument can be adjusted. One side of the condenser is kept at a nearly constant potential by means of a large number of small cells, while the other side is connected to line. The vibrating plate which bears on the condenser, by its motion, increases and diminishes the pressure, and hence the distance between the leaves. The principle of operation is as follows :—

The capacity of the condenser varies inversely as the distance between the plates, and when the capacity is varied by the varying distance, of the leaves apart, a current is set up momentarily in the line, which depends for its direction on whether the condenser is under or super-saturated for that value of its capacity. The general theory will be understood from the following. For convenience, we may consider any two contiguous sheets. Since the lines of force between the sheets cut them at right angles, the value of the force does not vary with distance, and since the electrostatic force is measured by the rate of change of potential, we have :

$$F = \frac{V_1 - V_2}{t},$$

where t is the distance between the plates. But the force near any electrified surface is $4\pi\rho$ where ρ is the density.

$$\therefore \quad \frac{V_1 - V_2}{t} = 4\pi\rho.$$

Hence

$$\rho = \frac{V_1 - V_2}{4\pi t}.$$

If S be the area of the plate then ρ S will represent the total charge.

$$\therefore \quad Q = \frac{V_1 - V_2}{4\pi t} S.$$

Hence for any variation in Q,

$$\Delta Q = \frac{V_1 - V_2}{4\pi} S \left(\frac{1}{t_0} - \frac{1}{t_1}\right) \quad . \quad . \quad . \quad (10)$$

or the variation in charge will be proportional to the change in *thinness* of the dielectric, since the reciprocal of the distance between the plates may be called the thinness. This thinness may, within the small limits with which we have to deal, be considered as proportional to the applied force. Then the variation in thinness will be proportional to the amplitude of vibration of the plate. Experiments made thus far with this instrument are encouraging, though its interest is more purely scientific than practical.

We have now examined the theory of a typical instrument of each class, and have found in each case, with varying degrees of approximation: (1.) That the amplitude of vibration of the plate was proportional to the kinetic energy of the sound wave. (2.) That the current on the line was proportional to the amplitude of vibration of the plate. (3.) Assuming the attractive effect of the current as directly proportional to it, the amplitude of vibration of the receiving plate is proportional to the strength of the current. (4.) That the kinetic energy of the sound emitted by the receiving plate is proportional to the amplitude of vibration of that plate, and hence the kinetic energy of the sound emitted is directly proportional to the kinetic energy of the initial sound. No time functions enter into any of equations (6), (8), and (10). Hence the action in every case is independent of the pitch of the note.

In equation (6) we see that the current depends on the change in $M\gamma$. As we have before remarked, this quantity may be considered as expressing the number of lines of force which pass through the conductor at any moment. Hence, to increase the current, the conductor should be so placed as to cut the greatest possible number of lines of force, and to allow of the greatest variation in the number of cutting lines for any given magnet strength. The electromotive force of the induced current will be proportional to the number of windings in the coil; the quantity to the electromotive force and conductivity of the circuit jointly, by Ohm's law.

The writer has experimented a great deal with the different forms of telephone, but more from a scientific than a practical point of view. Still, in the course of his experiments some facts have been reached that are worthy of notice. He has devised a form of instrument differing in construction from the ordinary Bell telephone, and having the advantage of greater ease and cheapness of manufacture. This instrument has been used by many scientific men who have visited the Stevens Institute, with the nearly unanimous opinion that it compared very favourably with the best yet constructed.

A sectional view of this instrument is shown in Fig. 4. The wooden case c, 4¼ inches in length by 2¾ in diameter, is, in the instrument made by the writer, of mahogany. Through this cylindrical block is bored a hole, 2 inches in diameter. Into this is fitted snugly the arrangement of magnets and coils tight enough to prevent its rattling about, but not so tight as to prevent its adustment by means of the screw S. Two horseshoe magnets are used; they are 3 inches long and can be bought at any toy store at a cost of about fifteen cents apiece. A com-

* The diagram should show a second binding screw, P_2, opposite to P.

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pound magnet is formed by superposing them, like pole over like, having a piece of wood T, $\frac{1}{8}$ inch in thickness, between them. A small piece of round iron or iron wire I, $\frac{3}{16}$ inch in diameter and $1\frac{1}{4}$ inches in length, is filed flat on two opposite sides to within about $\frac{5}{8}$ inch of the end—somewhat over half. One of the pieces is placed between the superposed like poles, and the whole is held tightly together by means of two screws passing through and into two pieces of wood *w w*. On the ends of *w* is screwed a strip of brass, *b*, which, by means of a screw thread in its centre, allows the whole arrangement to be moved in and out by the screw S. On the pieces of round iron E are slipped bobbins (which I have made of postal card, boxwood, or hard rubber), whose dimensions are: length $\frac{9}{16}$ inch, diameter $\frac{1}{2}$ inch, and core just large enough to fit snugly on *i*. They are wound with No. 38 wire, or for short lines coarser wire can be used. Connections are made in the ordinary way to binding posts p_1, p_2, and a disc of thin ferrotype, *f*, is placed over the end, and the magnets brought as near as possible without touching when the plate vibrates. The mouthpiece is like that of any ordinary telephone. One great advantage of this form is the ease with which a strong magnet can be made, and strength of magnet is an essential in the telephone. My instruments have a resistance of about 80 ohms, and I have worked them very satisfactorily on actual wires up to 75 miles and with resistances much higher. There is considerable choice in the ferrotype plates one meets with: the best that I have found is an imported article, of a maroon colour, and very thinly coated with varnish. The ordinary black American plates do very well, but the varnish is rather thick and they are not as satisfactory as the French. Of course the dimensions can be varied at pleasure, but the plate should not depart far from the size given, for if so, the fundamental tone of the plate will interfere with distinctness of articulation.

The writer has also experimented to some extent with a telephone which is a type of the second division of the first class of telephones. Two horseshoe magnets were placed about a quarter

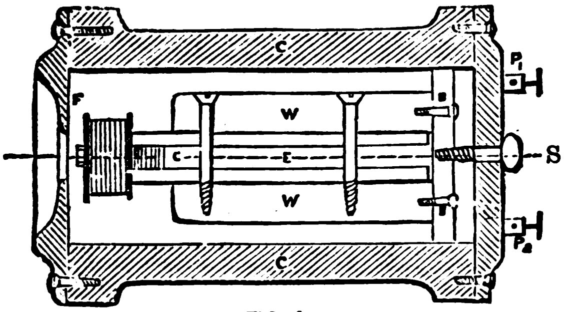

FIG. 4

of an inch apart, with the opposite poles facing each other, and a circular coil of such a size as to move easily between them, and whose diameter was such that the upper portion was between the upper poles of the two magnets, while the lower was between the lower poles. This coil was attached directly to a mica membrane, and when sounds were uttered before the membrane, the coil was thrown into vibration in the magnetic field, and the motion of the coil across the lines of force induced a current in the coil. Very fair results were obtained with this arrangement. This was also combined with the regular Bell telephone (Fig. 4) by attaching the coils to the ferrotype plate, and allowing them to vibrate to and fro on the round iron as a piston. In this case the coil was pushed across the lines of force, at the same time that the lines of force were drawn across the coil. The articulation of this arrangement was the best that I have yet heard on any telephone, though in my experiment it was not so loud as the regular form alone, probably owing to there being a want of sufficient freedom of motion in the coils, thus damping the vibration.

In the experiments made with the electrostatic telephone, I used some 200 cells, of small test-tube battery of simple zinc and copper plates in dilute sulphuric acid. The instrument had a capacity of about $\frac{1}{10}$ microfarad. While the results reached were not great enough to warrant more extensive investigation, they were sufficient to show that we had here a new means by which articulate and other complex sounds could be conveyed.

While experimenting on a wire of the Virginia Telegraph Co., the writer had occasion to notice more particularly a very curious fact which, from previous experiments, he had suspected before, that is, that the telephone seems to work more satisfactorily on a leaky line than on one perfectly insulated. His experiments were made on four wires. No. 1 was a wire, of the Western Union Telegraph Co., from Staunton to Charlottesville, Va., a distance of 40 miles. No. 2, a wire of the same company, from Staunton to Covington, Va., a distance of 70 miles. No. 3, wire of the Virginia Telegraph Co., from Staunton to Harrisonburg, a distance of 25 miles, and No. 4, one of the Baltimore and Ohio R. R., between the same points, 25 miles. On Nos. 1, 2, and 4, which were all excellently well insulated, the earth current was very marked, in some cases almost entirely drowning the sound of the voice, while on No. 3, a miserably insulated line, the earth current was comparatively insignificant, and conversation was carried on with the greatest ease. When this line was so nearly dead grounded that it was nearly impossible to work with the Morse system over it, the telephone worked to a charm. The writer has sought to explain this as follows, which, be it remarked, is only provisional, for the subject deserves more attention than he has been able to give it.

It would be difficult to choose two points, at any considerable distance apart, which would be at so nearly the same potential that when they were connected by an insulated line, no current would pass. If the line were perfectly insulated, the electro-motive force of the earth current would be proportional to the difference of potential of the points; hence, if this difference were great, the current would be great. On the other hand, if the line were leaking, this would allow of the readier equilibration of the potential at the terminus of the line and the leak, and of the difference between any two leaks, so that the earth current arriving at the distant telephone would principally be that due to the difference of potential of the nearest leak to the distant terminus and that terminus. The telephone current, of course, will lose in strength by being divided into so many branches, but being harmonic in its character, the successive currents reinforce the motion of the plate, hence a difference in the incoming current is not so readily perceived, and by adjusting, nearly as loud sounds can be obtained as if the line were insulated.

This observation agrees with the fact observed by others, that two wires could be buried in the ground and yet a telephone circuit made through them. Professor A. M. Mayer has experimented on a railroad track, using the two rails as conductors, and, badly-insulated and connected at switches as they were, good results were still reached. The writer has conversed with some ease between different floors of the same building, using the gas and water pipes as conductors. The same facts were observed with Mr. Edison's so-called "Etheric force;" and, in fact, many observations point to a close analogy between these telephonic currents and the "Etheric force," both being rapidly reversed currents. It should be noted that, in the above experiments, Nos. 1 and 2 ran north-east and south-west; while Nos. 3 and 4 ran essentially north-west and south-east. No. 4, though well insulated, was much better than 1 or 2. Such experiments give us some idea of the infinitessimal character of the currents active in this instrument, which, though escaping at every point almost, still arrive at a distance of twenty-five or fifty miles with sufficient strength to operate the telephone satisfactorily. One of the telephones used in these experiments when the plate was pressed in with the finger and held, gave, on a high resistance Thomson galvanometer, a deflection of only 1°. This points to the use of the telephone as a delicate electroscope, especially valuable where reversed currents are to be observed, as in Mr. Edison's "force," and with it very accurate measurement could be made, placing it in the cross of the "Wheatstone Bridge," or winding it differentially and balancing until no "click" was heard in the instrument at closing and breaking circuit. In fact, this is only one of the many uses to which it can be applied other than as a transmitter of speech or music, and from its wide adaptation, its beautiful simplicity, and the marvellous minuteness of the forces involved, it deserves to be classed, as it undoubtedly will be, among the greatest and most interesting inventions.—*Journal of the Franklin Institute.*

Stevens Institute of Technology,
Hoboken, N.J., March 30th, 1878.

DYNAMO-ELECTRIC MACHINES.

[CONTINUED FROM P. 39.]

Certain of the machines experimented with heated considerably on a prolonged run; most of the tests, therefore, were made when the machines were as nearly as possible at about the temperature of the surrounding air. It is evident that no other standard could be well adopted, as under a prolonged run the temperature of the different parts of the machine would increase very unequally; and, moreover, it would be impossible to make any reliable measurements of the temperatures of many such parts. In measuring the resistance of the machines, a Wheatstone's bridge, with a sliding contact, was used in connection with a delicate galvanometer and a suitable voltaic battery. In taking the resistances of the machines, several measurements were made with the armatures in different positions, and the

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mean of these measurements taken as the true resistance. It was, of course, a matter of the greatest importance to obtain a value for the resistance of the arc in any case, since upon the relative values of this resistance, and that of the machine, the efficiency would in any given case, to a great extent, depend. In each case the arc of which the resistance was to be taken was that which was obtained when each machine was giving its average results as to steadiness of light and constancy of the galvanometer deflection. The method adopted for the measurement of the arc was that of substitution, in which a resistance of German silver wire immersed in water was substituted for the arc without altering any of the conditions of running. This substituted resistance was afterwards measured in the usual way, and gave, of course, the resistance of the arc. It could, therefore, when so desired, serve as a substitute for the arc. No other method of obtaining the arc resistance appeared applicable, since the constancy of the resistance of the arc required the passage of the entire current though the carbons.

It may be mentioned that when the current flowing was great, the corresponding arc had a much lower resistance than when the current was small. This fact is, of course, due to increased vaporisation, consequent on increased temperature in the arc.

In determining the true arc resistance, the resistance of the electric lamp controlling the arc was measured separately, and deducted from the result obtained with the German silver wire substitute.

For ease of obtaining a resistance of German silver wire equal in any case to that of the arc, a simple rheostat was constructed, by winding upon an open frame, such a length of wire as was judged to be in excess of the resistances of any of the arcs to be measured. By means of a sliding contact, successive lengths of the wire were added until the conditions as above stated were reproduced. The same conducting wires were used throughout these experiments. Being of heavy copper, their resistance was low, viz., about ·016 ohm.

Having thus obtained the circuit resistances, we proceeded to determine the value of the current. Here the choice of a number of methods presented itself. We selected two methods, one based on the production of heat in a circuit of known resistance, and the other upon the comparison of a definite proportion of the current with that of a Daniell's battery.

In the application of the first method, eight litres of water, at a known temperature, were taken, and placed in a suitable non-conducting vessel. In this was immersed the German silver wire before mentioned, and the sliding contact so adjusted as to afford a resistance equal to that of the normal arc of the machine under consideration. This was now introduced into the circuit of the machine. All these arrangements having been made, the temperature of the water was accurately obtained, by a delicate thermometer, reading readily to quarter degrees Fahrenheit. The current from the machine running under normal conditions was allowed to pass, for a definite time, through the calorimeter so provided. From the data thus obtained, after making the necessary corrections as to the weight of the water employed, the total heating effect in the arc and lamp, as given in Table II., was deduced.

Since the heat in various portions of an electrical circuit is directly proportional to the resistance of those portions, the total heat of the circuit was easily calculated, and is given in Table III., in English heat units. For ease of reference, the constant has been given for conversion of these units into the now commonly accepted units of heat.

Having thus obtained the heating effect, the electrical current is readily determined by the well-known formula,

$$C = \sqrt{\frac{W h \times 772}{R t c}}.$$

where C = the veber current per ohm*, W the weight of water in pounds, h the increase of temperature in degrees Fahr., 772 Joule's constant, R the resistance in ohms, t the time in seconds, and c the constant, ·737335, the equivalent in foot-pounds of one veber per ohm per second. The currents so deduced for the different machines are given in Table IV.

The other method employed for obtaining the current, viz., the comparison of a definite portion thereof, with the current from a Daniell's battery, was as follows: a shunt was constructed, of which one division of the circuit was ·12 ohm, and the other 3,000 ohms. In this latter division of the circuit was placed a low resistance galvanometer, on which convenient deflections were obtained. This shunt being placed in the circuit of the machine, the galvanometer deflections were carefully noted. To the resistance afforded by the shunt such additional resistance was added as to make the whole equal to that of the normal arc of the machine. These substituted resistances were immersed in water, in order to maintain an equable temperature.

* C is here simply the current in vebers per second.—Ed. E.

Three Daniell's cells were carefully set up and put in circuit with the same galvanometer used above, and with a set of standard resistance coils. Resistances were unplugged sufficient to produce the same deflections as those noted with the shunt above mentioned. The shunt ratio, as nearly as could conveniently be obtained, was $\frac{1}{25000}$. Then the formula,

$$C = \frac{s\,n \times 1{\cdot}079}{R},$$

where C equals the veber current, s the reciprocal of the shunt ratio, n the number of cells employed, 1·079 the assumed normal value of the electromotive force of a Daniell's cell, and R the resistances in the circuit with the battery, gives at once the current. In comparison with the total resistances of the circuit, the internal resistance of the battery was so small as to be neglected.

The results obtained were as follows:—

Name of Machine.	Shunt ratio,	Number of Daniell's cells.	Resistances unplugged.	Speed of Machine.
Large Brush	$\frac{1}{25000}$	3	2,710 ohms.	1,340 rev.
Small Brush	,,	,,	3,700 ,,	1,400 ,,
Wallace-Farmer ...... {	,,	,,	8,320 ,,	844 ,,
	,,	,,	6,980 ,,	1,040 ,,
Gramme	,,	,,	4,800 ,,	800 ,,

The veber currents, as calculated from the above data, are given in Table IV.

From the results thus derived, the electromotive force was deduced by the general formula,

$$E = C \times R.$$

The electromotive force thus calculated will be found in Table IV.

Statements are frequently made, when speaking of certain dynamo-electric machines, that they are equal to a given number of Daniell's, or other well-known, battery cells. It is evident, however, that no such comparison can properly be made, since the electromotive force of a dynamo-electric machine, in which the reaction principle is employed, changes considerably with any change in the relative resistances of the circuit of which it forms a part, while that of any good form of battery, disregarding polarization, remains approximately constant. The internal resistance of dynamo-electric machines is, as a rule, very much lower than that of any ordinary series of battery cells as generally constructed; and, therefore, to obtain with a battery conditions equivalent to those in a dynamo-electric machine a sufficient number of cells in series would have to be employed to give the same electromotive force; while, at the same time, the size of the cells, or their number in multiple arc, would require to be such that the internal resistance should equal that of the machine.

Suppose, for example, that it be desired to replace the large Brush machine by a battery whose electromotive force and internal and external resistances are all equal to that of the machine, and that we adopt as a standard a Daniell's cell of an internal resistance of, say, 1 ohm. Referring to Table IV., the electromotive force of this machine is about 39 volts, to produce which about 37 cells, in series, would be required; but, by Table II., the internal resistance of this machine is about ·49 ohm. To reduce the resistance of our standard cell to this figure, when 37 cells are employed in series, 76 cells in multiple arc would be required; therefore, the total number of cells necessary to replace this machine would equal 37 × 76, or 2,812 cells working over the same external resistance. It must be borne in mind, however, that although the machine above mentioned is equal to 2,812 of the cells taken, that no other arrangement of these cells than that mentioned, viz., 76 in multiple arc, and 37 in series, could reproduce the same conditions, and, moreover, the external resistances must be the same. The same principles, applied to the other machines, would, when the internal resistance was great, require a large number of cells, but arranged in such a way as to be extremely wasteful, from by far the greater portion of the work being done in overcoming the resistance of the battery itself.

TELEGRAPHIC COMMUNICATION WITH THE MAURITIUS.

At the meeting of the Chamber of Commerce, on the 13th ult., the question of telegraphic communication with these islands was considered, and it was again suggested that the Chamber should exert its influence with the home authorities that Mauritius should be included in any system which provides telegraphic communication with the Cape.

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THE ELECTRICIAN.

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NOTICE TO EDITORS.

We shall be happy to exchange with the Editors of Scientific journals who receive the first numbers of THE ELECTRICIAN.

Nous serons heureux de faire l'échange avec Messieurs les Rédacteurs des Journaux scientifiques qui recevront les premiers numéros de L'ELECTRICIAN.

Es wird uns ein Vernügen sein mit den löblichen Redactionen der deutschen und anderen continentalen Journäle und Zeitschriften, denen die ersten Nos. des ELECTRICIAN *zu Händen kommen möchten auszutauschen.*

I Signori Editori di giornali scientifici che riceveranno i primi numeri dell' ELECTRICIAN *ci faranno cosa gradita accettando il cambio che loro offriamo.*

SOUTH AFRICAN TELEGRAPHY.

The question of telegraphic communication with our South African possessions is rapidly assuming definite shape. Of the several alternative routes that have been proposed for effecting this most desirable object, and which offer a veritable *embarras de richesses*, none present so many points in their favour as that along the East Coast from Aden, *viâ* Zanzibar and Mozambique either to Delagoa Bay or Port Natal, with a branch line from Zanzibar to Mauritius, tapping Madagascar at its northern extremity. Its marked superiority over any of the western lines *viâ* the Atlantic, either by deep sea cables from the Cape Verd Islands to Ascension, St. Helena and the Cape, or by coast lines by Senegal, Upper and Lower Guinea, and Walfish Bay, we had recently occasion to dwell upon. Lately, however, it has found a rival in an overland route across the eastern side of the Dark Continent in its entire length north and south. As this scheme has been highly spoken of, and, indeed, warmly recommended by no less an authority than Mr. J. Sivewright, at present in charge of the Telegraph Department, Cape Colony, we are likely to hear a good deal about it for some time to come; hence it may be useful to examine its merits, and once for all dispose of its pretensions to serious consideration.

It proposes to carry a wire from Natal and Transvaal through Matebeleland northwards to Tete, Sena, or some other point on the Lower Zambezi, thence *viâ* Lake Nyassa or the country east of it to Zanzibar, and so on through Usagara, Unyamuesi, and across Lake Victoria Nianza to Uganda, and down the Victoria Nile to Gondokoro, or rather Lado, on the White Nile, where it would form a junction with a line connecting Egypt with its recently-acquired equatorial provinces. But, notwithstanding the eloquence with which it has been advocated in some quarters, this project will scarcely bear serious discussion. The line, however judiciously chosen, would necessarily have to traverse no less than four-and-twenty parallels of latitude, or some 1,650 miles of country, from the Limpopo River on the northern frontier of Transvaal to Magungo on the southern frontier of Egyptian Sudan, a country either totally unknown or but partially explored, with a dangerous climate, infested in many places by the tsetse fly, and inhabited mainly by fierce and unfriendly tribes.

No doubt, an apparently similar *tour de force* was successfully performed in 1872 in Australia, where the wire has been laid down for a distance of 1,973 miles right across the Continent, from Adelaide on the Southern to Port Darwin on the Indian Ocean. But the circumstances are so entirely different that the astonishing success of this magnificent undertaking cannot be appealed to as a precedent. Before the attempt was made, the unknown country between South Australia and the northern territory was roughly explored by J. M'Douall Stuart, and was found to present far less serious physical obstacles than had been anticipated. The country was especially free from troublesome native tribes, except near the M'Donnell Range, and at one or two other points, where the judicious application of a few electric shocks was sufficient to inspire the aborigines with a permanent and wholesome respect for "the whitefellow's devil." But the warlike, powerful and intelligent Mazitu, Wamasai, Wanyaturu, Waiyau, Lomwé, and other East African Bantu nations, are not to be so easily disposed of. Nor would it be possible to subsidise them, so numerous are the independent chiefs, especially in the region east and north of Lake Nyassa, all of whom would have to be dealt with separately. These districts may be said to be in a chronic state of petty warfare, and are from time to time laid waste, especially by the fierce Mazitu and Wamasai predatory hordes under such formidable leaders as Mirambo, who generally make a clean sweep of everything, and would not be at all likely to spare the telegraph poles. These objects, if "fetish," and therefore sacred in the eyes of one tribe, would in all probability be regarded with all the greater aversion by their neighbours. In any case, if we have not yet acquired influence enough to put down the detestable slave trade still openly carried on in these regions, or to induce the natives to allow free passage to an occasional explorer or missionary without subjecting them to oppressive exactions, the time must be still remote when we shall be in a position to keep open an overland line along the proposed route, except at an utterly ruinous expense. When it is added that such a line could under no circumstances develope any local traffic, except at Zanzibar, and at its extreme ends north and south, that its repair would be always a difficult and costly matter, and that the scheme itself is for the present at least *in nubibus*, it seems scarcely deserving of a moment's consideration when compared with that already carefully thought out and matured by the practical and experienced minds connected with the Eastern Telegraph Company. This powerful and influential corporation has applied itself to the solution of the problem, and has pronounced emphatically in favour of the route along the eastern seaboard, which thus promises soon to pass from the regions of fancy and theory to the world of realities.

Including the contemplated branch from Zanzibar to the Mauritius, not by any means the least desirable part of the project, the length of cable required by this route to connect the Cape and Natal with Aden and the rest of the world would be either 5,520 or 5,260 miles, according as it might be landed at Natal or the Portuguese station of Lorenzo Marquez, Delagoa Bay. At the rate of £250 per mile, the price for which the Telegraph Construction and Maintenance

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Company have actually undertaken to construct and lay such a line, there would be needed a capital of about 1,380,000*l.*, which might be raised under an Imperal guarantee at 3¼ per cent. The interest on this sum (44,850*l.*), together with the general charges for working expenses, stations, repairing ship, &c., would involve a yearly outlay of, perhaps, 66,000*l.*, and as the line is not calculated to yield for the present more than 40,000*l.* of revenue on traffic, there would be a clear deficit of something like 26,000*l.* It should, however, be remarked that, whereas none of the proposed alternative routes could possibly be commercially remunerative at first, if at all, the deficit in this case would be amply covered by the subsidies already either promised or anticipated from the several Colonies or States directly interested in the undertaking. In this way, 5,000*l.* might be reasonably expected from the Sultan of Zanzibar, 5,000*l.* from Réunion, 10,000*l.* from Mauritius, the same from the Cape, 5,000*l.* from Natal and Portugal, altogether about 40,000*l.*, leaving for shareholders a net profit of 14,000*l.* at once, with a fair, not to say a certain prospect of a steady increase of traffic in such places as Transvaal, Mauritius, Madagascar, and Zanzibar.

But, even should some of these promises prove delusory, we understand that the Eastern Telegraph Company is still prepared to make such liberal arrangements with the British Government and the Colonies for the working of the new line as would amount practically to an annual subsidy of about 19,000*l.*, thus securing, under the most adverse circumstances, a surplus income of at least 20,000*l.*, from the commencement.

There can be little doubt that, should this route be adopted, a cable would eventually have to be laid down between Mauritius and Ceylon—a distance of not more than 1,700 geographical miles. The South African Colonies would by this means be brought into direct telegraphic connection with India, China, Japan, Australia, and New Zealand, whereas by the West Coast line their communication with these important regions would have to be made by a most circuitous route, *viâ* Cape Verd Islands, Lisbon, and the Mediterranean, involving a practically prohibitive tariff and the constant risk of interruption between the Cape Verd Islands and Lisbon, where there is only a single deep-sea cable. This point alone ought to outweigh all other considerations with our antipodean brethren, who, when they come to study the matter in all its bearings, will scarcely fail to recognise the overwhelming advantage presented by the East Coast route over all the alternative projects hitherto proposed.

ERRORS IN TELEGRAPHY.

BY SIR JAMES ANDERSON.

In the criticism of my articles upon this subject, by "Anglo-Indian," we now have the question represented from the merchant's point of view, and I shall indulge in the hope that when both sides have fairly expressed their opinions, the points of divergence may be lessened by common accord.

"Anglo-Indian" complains that, in adopting the ten-letter limit, forbidding the use of five-letter groups, and charging double for five-figure groups, we reduced the *facilities* previously enjoyed by merchants from 12,242,487 available ciphers to 125,000, and that we raised the tariff from 4s. per word to 4s. 6d. This latter statement does not represent the case accurately. The tariff was *not* 4s. per word, but a minimum of 2*l.* per ten words, and then a word rate, and we consider the adoption of the one-word tariff at 4s. 6d. a considerable reduction.

As to the five-letter groups, mixed with five-figure groups, they had become so great a nuisance, and so unprofitably absorbed the transmitting capacity of the lines, that it became imperative for the companies to consider some method of *being paid for the work done.* That is the key to every change which has been effected, and it must continue to be so. Therefore, whenever "*freest facilities,*" "*philological principles,*" "*all legitimate word-combinations,*" "*use of legitimate ciphers to any number,*" are pressed upon us, as they now are by "Anglo-Indian" and others, they must be considered side by side with the necessities of the Telegraph Administrations to receive *payment for work done and service rendered.*

I have stated in a former paper that the proprietors of cable property were asked to find money upon a transmitting capacity of so many words per minute, and that these words were based upon an average of five letters per word. The present average is seven letters, and we are now expected to adopt an average of 9 3-16. "Anglo-Indian" would make it appear that I had very much overstated the case when I said that, "generally speaking, all Whitelaw's words would be ten letters." I have now given the exact average.

Prior to the formation of these companies the tariff to India was 5*l.* for twenty words. The companies tried the reduced tariff of 2*l.* 17s., and were on the point of being ruined. In 1872 the tariff was raised to 4*l.* 10s. for twenty words, and the average length of a message with that tariff was twenty-five words, or 5*l.* 12s. 6d. per message. To-day the tariff is 4s. 6d. per word, and the average length of a message is fifteen-and-a-half words, or 3*l.* 9s. 9d. per message, and this average is arrived at by including political news and packers' messages. Merchants avail themselves of the facility of sending messages of three or four words.

The power of concentrating large transactions, and expressing very many words in one or two code words, has increased beyond anything ever contemplated, and has had the effect of keeping the revenue of this company almost stationary.

We carry almost the whole of the traffic to and from Egypt, and as I possess all the data I will give the result as illustrating the effect of reduction of tariff, and the adoption of the single-word rate, which is practically another method of reducing the tariff. In 1868 the tariff between London and Alexandria was 40s.—afterwards reduced to 30s.—for twenty words. In 1873 we adopted a ten-word tariff of 1*l.*, and in 1876 the word-rate pure and simple came into force. The result was that in 1876 and 1877 we transmitted *double the number of messages*, and we earned in 1876 8,359*l.*, and 1877 9,408*l.* *less* revenue than was earned for half the number of messages carried in 1871. At this latter date the length of messages was thirty words. Last year it was fifteen and a half, and thanks to the "free facilities" the *single rate for code-words*, and the gradually increasing knowledge of concentrating mercantile wants in few words, this average is becoming, every time I investigate the matter, still more reduced.

Many messages consist only of four figures, and others of only four words. The traffic grows, but the revenue does not increase, as our customers seem persuaded it must do if we remove all restrictions and permit them to do just as they please, not presuming to have an opinion ourselves even though we are daily watching the effect of every change.

With the desire to understate rather than exaggerate, I have assumed the average of code words to express only *six* real words. Some single code words I know express only four, but others express forty and upwards. If six be a fair average, then each word from London to Bombay is only charged 9*d.*, or less than ·11 of a penny per 100 miles by the longer route, and by the shortest route about ·22 of a penny per word for each hundred miles. At this tariff the mercantile public and all international interests enjoy the insured communications of two direct cables and two other distinct land and cable routes to India.

These words traverse the whole distance by two of these routes within a space of time varying from forty minutes to two hours. Every individual letter has to be transmitted six times, and when corrections are required they cannot be done otherwise than by a retransmission of all the letters of the word in question, and, in addition, all the letters of each word necessary to demand the repetition. Surely, this establishes a right on the part of the companies to ask for simple and intelligible language, which, as I have already stated, can be transmitted *twice as fast* as the code words now creeping into use, and four times as fast as the five-letter groups mixed with five-figure groups.

The lower, therefore, we can keep the average number of letters in words, and the simpler these words are, the faster we can transmit and the fewer corrections are required. Both of these conditions, if observed, would be a clear gain to the telegraphing community, and, what is all important to companies, give *them* a reserve of transmitting capacity to meet the increase of traffic we hope to enjoy on the revival of trade.

It would not argue much forethought on our part if we did not recognise that code language comprised of words of seven syllables, such as "incomprehensibleness" or "versecherungsgesels-chaft" referred to by "Anglo-Indian" would soon block the cables, and require *an increase of capital for new cables to carry unprofitable work.* It may be that the managers of the American

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Cables have not cared for a few such words in a week's work, but make a code of such monsters, and they must soon cry out. As a matter of fact, the odd unintelligible combinations which are growing so fast upon our Eastern lines are comparatively rare upon the American lines.

It is true we have tolerated some objectionable code words for about a year. We hoped they might be rare, or at least not general, and, although cognisant of their existence, we did not see it necessary to make a stand against them until the representation to the Postmaster-General of a number of the "leading firms in the Eastern Trade" showed that we had a system to look in the face which claimed to be considered upon the correctness of its philological principles.

I will assume that Mr. Whitelaw's word-combinations are philologically correct, and it may be that the language is enriched by eminent authors constructing such words as "Dryasdust," "Dotheboys' Hall," &c. But, if these examples are to establish the rule and usage of the language, instead of being facetious exceptions, then we must admit that "Taken-at," "sell-to-arrive," "buy-at-best," "sell-at-best," and all such like combinations, would be equally legitimate.

Any of these, with a vast number of similar combinations, might be used in a work of fiction as the cognomen of an individual, or be applied to an imaginary hall, bank, or grove. They might stamp some angularity of character or peculiarity of place, and be so happily selected as to become known wherever the language is spoken, but, surely, there is a wide difference in once for all coining and writing an exceptional word which can be reproduced by the million with the printing press, and building up a telegraph jargon of unintelligible gibberish, limited only by a ten-letter restriction, every letter of which has to be transmitted six times between here and India. We should require a staff of trained philological detectives to know whether we were dealing with words which could consistently emanate from any langugae, or were being imposed upon us by capricious combinations. Whatever can be said for the genius of our own or any other language, it was never contemplated that such words as the following, from Whitelaw's code, were to be coined and claimed as according to the usage of the language :—

ENGLISH.	GERMAN.	INDIAN.
Fulkewards	Eykenmuhle	Damyarawza
Haconcarse	Forckpfuhl	Ekrupchbor
Nithshythe	Metkekuste	Hujamgaukh
Pledgditch	Ovinksumpf	Kavudkushk
Ulphmead	Smitzbosch	Tyoortukka
Valpykilns	Zweegfahre	Ukoordwip

Many of such words are and all can be used to indicate separate parts of transactions in a single word.

The following are specimens of another kind we have been favoured with :—

Actingness	Breathedly	Carefuling
Dutably	Fearfulbly	Givingness
Hookeding	Jumpedful	Kisserton
Laughation	Neededly	Ownedless
Pitiestful		

The following sixteen variations and combinations of the word "love," to which we do not object because they are dictionary words, will give an idea of the extent to which irregular combinations may be carried :—

Love	Lover	Lovable	Lovably
Lovest	Lovage	Lovely	Loved
Loveless	Lovelorn	Lovesick	Lovesome
Loving	Lovingly	Lovelock	Loveknot
Lovetale			

By the use of the three prefixes "ab," "ba," "co," and four affixes "ly," "son," "ing," "ness," 93 additional word-combinations may be made.

There are numerous other prefixes and affixes, but I have confined myself to a few that we know to be in use, whilst cases are not wanting where both the prefix and affix have been attempted in the same word. Thus :—

Abloverly, Coloverson, &c.

Such combinations can be so arranged that each word expresses not only a given quantity of goods, but price, freight, and destination.

If "philological principles" and "freest facilities" are to carry with them the privileges of constructing such outrages upon language, then, if they were adopted, these companies would soon exist only for the profit of merchants and packers.

It is not possible to shut our eyes to the fact that unlimited combination must mean reduction of revenue unless the tariff is raised. Whenever the question of altering tariffs or the length of words has been considered, there has always been a sincere desire to go with the commercial stream as far as possible, so long *as we get paid* for work done. The Anglo-American Company was the first to adopt the word tariff. The other companies urged it upon the conference at Rome and obtained the concession. The arguments in favour of the system were :—

1. Merchants naturally desired to communicate their transactions in *secret language*, and we urged that we did not care what the words meant so long as they were intelligible, such as could be found in dictionaries or gazeteers, and we advised a single rate for a code word, whatever it meant. The tariff formerly was a rate-and-a-half for secret words.

2. We believed that, if merchants were allowed to register one word as their address, and to telegraph one, two, three, or more words as and when they pleased, and these words allowed to have a secret meaning, the use of the telegraph for minor as well as large transactions would grow, and this has been the result, but not yet giving us the pecuniary success anticipated. And in some important instances it has been most unsatisfactory in that respect. Practically, however, we all believe that the word tariff is sound in principle, and that it should be exhaustively tried before another change is advanced.

We are fully alive to the effect of code language and word tariff upon mercantile transactions. They promote inquiries which lead to business or prevent unprofitable business. They create transactions which demand explanations or confirmations. And this is the very essence of the growth of telegraphy. On the other side, it enables transactions to be carried on with one quarter the capital which the same amount of business would have required ten years ago. It opens up more scope for the merchant. He can control his ships and regulate his transactions at all the ports in the world, and "Anglo-Indian" tells us there are now 125,000 admissible cipher words which can be found in dictionaries and gazetteers by which this can be done, and to which the companies offer no objections, but only crave consideration for the difficulty of sending accurately words which are in their telegraphic symbols too much alike.

In article 3 "Anglo-Indian" makes light of my selection of only 14 out of 300 affixes being like another 14, and remarks that I say nothing of the prefixes; but my argument is that these affixes can all be applied, and in practice they have been applied to 363 prefixes in English, 269 prefixes in German, 368 prefixes in Indian, making a total, as formerly stated, of 10,579 words, or over 10 per cent. of the 100,000 word combinations. And, further, that these affixes and prefixes, arranged as proposed, for the purpose of combination, enables the packer or merchant to build up a new system of hitherto unknown words which can have no other use or value than reducing our revenue to their sole advantage and to our disadvantage in other respects besides loss of revenue.

This new system of words was not contemplathd when the word tariff was introduced. It would not be paying us for the service we undertook to render at a given price. And we have a right to claim that we knew what we meant when we made the contract with the public. If something else is to take the place of ordinary intelligible language, the conditions will be changed, and we shall have a right to reconsider the contract. "Anglo-Indian" would like to establish that the St. Petersburg Conference, in adopting the words "word combinations not contrary to the usage of language," meant something very different to "words in dictionaries or gazetteers." We who represented the companies at the different conferences maintain that we can recognise no other guides than dictionaries and gazetteers.

"Philological principles" had not hitherto been introduced as an element in the question, and now that they are I do not believe they will grow in favour, but the importance of the subject is brought to the front, and it should not rest until the telegraphing community and the Telegraph Administrations are agreed. It may lead to a *single letter tariff*. For some years this idea has had supporters amongst us, but it means *illimitable combinations*, and whenever tried will be so much of an experiment that the tariff at starting must be relatively *very dear*.

It is altogether a mistake to assume whenever a reduction of tariff or a facility, which is practically the same thing, is established, that the telegraph is at once so much more resorted to that the revenue is recouped or increased. It is always a long time before the one point or the other is reached.

The best illustration of this fact is afforded by the introduction of the penny post, which has in numerous instances been referred to, but remains apparently unheeded whenever the question of cheapness in the interests of the public is brought forward. It was eleven years before the same gross revenue was reached, and twenty-three years before the same net revenue was obtained which existed prior to the reduction.

No one telegraphs more than he can help. It is impossible, in face of the daily illustrations to which my attention is called, not to see that the first effect of code-words and the single-word tariff has been and is a loss.

One connot help seeing hundreds of telegrams of one, two or

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four words sent by people who used to send almost as many when the minimum was ten and twenty words. I know there are those who claim that they spend as much money upon telegrams now as they used to do when the tariff was 5*l.* and 4*l.* for twenty words, and I have no right to doubt it, but such is not the case in the aggregate.

If the tariff to India was lowered to-morrow to 2*s.* per word the increase would probably be 50 per cent. more messages and about 40 per cent. less revenue. Such was the result with the Anglo-American Company.

In 1875 the tariff was 4*s.* per word. The daily average number of messages was 697, and the daily average receipts 1,927*l.* The tariff was reduced to 2*s.*, and the messages each day were 917, and the receipts per day 1,183*l.* Then the tariff was reduced to 1*s.* per word, and the messages per day were 1,254, and the receipts 824*l.*, just one third of the money obtained with the 6*s.* tariff in 1873 for carrying 588 messages per day.

Whilst giving my attention to this subject I find myself leaning to the conviction that, rather than become involved in combating capricious philological combinations of all the languages in the world, it would be better to examine at once the merits of the single letter principle, and determine at what tariff such a system might be adopted.

I regard this as the only solution, *if dictionaries and gazetteers are not sufficient* to establish the usage of language.

The advantages must not be all on one side. Government telegraph systems do not pay, and not one of our large cable companies is earning enough to pay a dividend in any degree proportionate to the risk, and at the same time laying by sufficient reserve. All the duplications of cables, payment of large sums for duplexing and for improved instruments necessitating skilled clerks, and an increased number of them, all the reductions of tariff from 20*l.* for twenty words with which the Anglo-American Company commenced, and from 5*l.* for twenty words to 4s. 6d. for one word upon the lines to India, the admission of code-words at single rates, the registration of one word for an address, are amongst the *facilities* which the companies, of their own accord, have established so far, almost altogether for the benefit of the public, but with the object of promoting the growth of telegraphy, and in the faith that the revenue would soon increase.

The free use of the telegraph is growing, but the revenues cannot possibly grow if we are to admit unlimited combinations and the manufacture of a telegraph language at the present tariff. It is all a question of tariff, and those who are daily watching telegraph business as it is developing must claim some right to estimate and understand the wonderful advantage the code-word system has been to the mercantile community and the very disappointing effect it has upon the companies' revenues.

I propose these observations shall now close my contribution to the literature of this subject. Whatever more may be said or written by others will no doubt be duly considered when the subject is brought forward at the next Telegraph Conference.

CORRESPONDENCE.

HUGHES'S MICROPHONE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I notice with regret that Mr. Edison has been trying to make the American public believe that he also invented the microphone, and that simply because in his carbon telephone he made use of a button of carbon, the varying pressure of a diaphragm upon this producing a varying current of electricity. In all his attempts, as far as I can learn, he has never varied from this idea. He has made thin and thick diaphragms, tried many kinds of carbon, &c., but in all the principal remains the same. The use of carbon as a varying resistance with varying pressure did not originate with Mr. Edison. Mr. Clerac, electrician of the French Government Department, supplied me with resistance tubes founded upon this principle in 1866, viz., a glass tube containing powdered carbon, the resistance of which was regulated by the varying pressure of a regulating screw pressing on the carbon. Mr. Edison claims this resistance tube as an original invention or discovery in 1873, or seven years after it was known in Europe, and he will find in the *Journal Télégraphique*, Berne, 1873, that the invention was claimed by a German; but on Mr. Clerac proving his priority, in 1866, it was freely accorded him. So much for the resistance carbon tubes of Mr. Edison and the principle of which he acknowledges he has adopted in his carbon telephone. As a coincidence, it is curious that the date, 1873, of Mr. Edison's claim to these resistance tubes should be the same, when the invention of 1866 was again brought prominently into notice by the remarks in the *Journal Télégraphique*. I am willing to believe Mr. Edison was ignorant of these facts until the present time, but he ought now to investigate this and give credit where credit is due.

The microphone, the principle of which I discovered, and after many months incessant labour and study invented the numerous forms now in use, is entirely different in principle, form, uses, and results, to the carbon transmitter of Edison. There is no diaphragm, thick or thin, there is no mechanical apparatus by which the sounds are directed or concentrated upon the electrical conducting material, no arrangement to obtain a varying pressure, as we need really a constant one. There is not the slightest necessity for the use of carbon at the contact points, as all metals which do not oxidise act equally well. The sonorous vibrations are taken up by a piece of pine board or any resonant material, and if, on any part of this board, no matter how distant from the speaker or source of sound, two electrical conductors are placed under a very slight but constant pressure, these conductors vibrate exactly as the molecular agitation or vibration of the board, and of themselves, without any regulation, without any change of pressure, transforms a constant electric current into waves in exact form with the sonorous vibrations. The effect is wonderful, so much so that the highest scientific intellects of Europe have been struck with surprise and astonishment that such unheard-of effects could be produced from an apparatus and causes so apparently simple. In some of the forms of microphones, I use carbon at the contact points, and, if I believed for a single instant that Mr. Edison was the first to use carbon for electrical purposes or for contact points, I would use platinum or gold points, which are equal to, if not superior to carbon, though not so cheap; but, as carbon has long been used in electrical batteries, electric light, resistance tubes, and relay contacts by myself, I see no necessity to abandon its use simply because Mr. Edison happens to use it in his carbon telephone in a totally different way, and for different reasons, from its use as contact points in the microphone.

The London agent of Mr. Edison, Mr. Adams, presented to the Post-Office Telegraphs, about eight weeks since, Edison's carbon telephone, and as it was publicly exhibited, I saw it in company with many others. It consisted of an Edison transmitter, and an exact copy of Professor Bell's receiver which he calls an Edison receiver.

The transmitter consisted of a diaphragm (same form and materials as Professor Bell's) pressing upon a button of carbon, the varying pressure of the diaphragm upon the carbon producing a varying current of electricity. It was complicated, required not only the use of batteries, but induction coils, and the results were not superior to those of Professor Bell's against which it was tried in my presence. The Edison receiver was identically the same as Professor Bell's, the only difference being that the natural magnet was brought round so as to touch the diaphragm; in fact, it was so transparent a device to infringe Bell's patent, that the Bell Company at once said they would not permit its use. If Mr. Edison thinks there are points of resemblance between his carbon transmitter to Professor Bell's telephone, and anything I have done, it is quite a proper subject for discussion in the scientific journals, but quite unsuitable (being one of a technical nature) for discussion in public journals of general interest, and the technical part of the question must henceforth be discussed by those who are in full possession of the facts and are capable of judging.

As regards my heat measurer: soon after my paper to the Royal Society, requiring some glass tube and not finding it, I used a quill pen which happened to be on the table; I found the quill very sensitive to heat, and some friends and journalists visiting me soon after, I showed them the remarkable sensitiveness of this ordinary quill to heat. The *Engineer* and *Electrician*, owing to my hurried explanation, having so many more important experiments to show, thought the effects were due as a thermopile, and gave it in a notice prominence it did not require. I thought then, and think still, that the matter was of no practical importance, as we have already such excellent and sensitive heat measurers, each suitable for some special experiments. Mine has long since gone in my waste experiment box, and, if Mr. Edison has made a very similar one, and thinks it of value, he is welcome to his own and mine too, and I should recommend him to try a quill in place of the vulcanite I have lately seen described.

Mr. Edison has made publicly a gross personal attack upon the honour of Mr. Preece and myself, and this part he must prove as publicly as he has made it, or stand confessed a wilful slanderer.

His message to Sir W. Thomson, London, says: "Edison to Sir W. Thomson. Direct impact carbon, telephone sent Preece two months ago, also publications and letters describing its use as heat measurer, great abuse confidence, his part in Hughes' matter—I send you publications of proofs."

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This message seems carefully worded, although it insinuates an abuse of confidence on Mr. Preece's part. The carbon telephone received through his agent, Mr. Adams, two months since, I have already mentioned; but I had already shown mine some weeks before its arrival at the Post Office, and had tried them in January and February at the Submarine Telegraph Company in presence of its officers. There has been no secret as to the effects of my microphone since last January; but the secret of its action was divulged for the first time in presence of Professor Huxley, Mr. Norman Lockyer, Mr Conrad Cooke, and Mr. Preece, on May 2 last, when it was decided that I should bring my discoveries before the Royal Society, which was done the following week—Mr. Preece could see no resemblance then or since between my microphone and Edison's carbon telephone—and consequently had no confidences to make me, even if he possessed any from Edison, which I do not believe he had; but, even supposing he had informed me then that Mr. Edison was also trying to make a microphone, it would not have prevented me from at once presenting to the world the microphone I had discovered, made, and exhibited at the Submarine Telegraph Company many months before. So it was a gratuitous insult to Mr. Preece and to myself to insinuate that—simply because he sent a carbon transmitter to the Post Office for trial, through his own agent, Mr. Adams, and that publicly—I should have taken hints, from such a failure as it proved to be, to improve that which had already been found successful months before. It bore no resemblance to the microphone in its objects and effects; the main object of Edison's telephone appeared to me to be to avoid Professor Bell's magneto transmitter by producing the same effects of telephony in a different way; the main object of the microphone is to render audible sounds hitherto inaudible, and thus to allow us to investigate a new and wonderful world—and a mere glimpse, or, in fact, a long study of Edison's carbon transmitter would not have helped the matter in the slightest. Had I been inclined to imitate, it would certainly have thrown me on the wrong track as it did him.

Mr. Edison, however, has gone still further. He has sent to the French journals, and published in *Le Figaro*, June 24, and *Correspondance Scientifique*, June 25, the following which he declares that he sent to Sir William Thomson:—

"*Edison—Sir William Thomson.*

"J'ai envoyé des microphones a MM. Preece et Hughes, il y a deux mois, et aussi des descriptions de cet appareil, il y a abus de confiance de la part de Mr. Hughes dans cette affaire, attendez mes preuves.

"Menlo Park, June, 1878. "EDISON."

"*Translation.—Edison to Sir William Thomson.*

"I have sent some microphones to Messrs. Preece and Hughes two months since, and also some descriptions of that instrument; there is an abuse of confidence on the part of Mr. Hughes in that affair, await my proofs. "EDISON."

This will be seen to be very differently worded to the one really sent to Sir William Thomson, and states directly that he sent me microphones, and that I abused this confidence.

In answer, I have only to say that I have never received any microphones, any carbon telephones, any instrument, any description, letter, or communication from him, direct or indirect, at any time whatever.

This I state emphatically, and now call on Mr. Edison to prove the truth of his message I have just quoted from the French journals; and no further technical discussion can take place until he furnishes such proof.

If he fails in proving the truth of the above message, as he surely will, his conduct will merit the contempt it will receive.

D. E. HUGHES.

SS. SHERARD OSBORN AND CABLE-LAYING.

[CONCLUDING PAPER.]

The picking-up gear is used in grapnelling for the cable, lifting the bight to the surface, and picking up the cable towards the fault. The paying-out and picking-up machinery have been combined in one, but generally they are quite separate, the picking-up gear being near the bows of the ship, and the paying-out near the stern, which are the most suitable positions for each. The picking-up gear consists of the drum A, wheels B and C keyed to the shaft D, wheel E keyed to the shaft H, and wheels F and G, either of which is free to move independently of the shaft, or by means of a clutch is made to revolve with it. The wheel I is keyed to the driving shaft, and the whole of the machinery is driven from this by a double-cylinder engine, the steam for which is supplied from the main boilers of the ship.

The draw-off motion, consisting of the V wheel K and the jockey wheel L, is driven by a system of bevel wheels MM from the main shaft D. The machine is also provided with a powerful break (not shown in the drawing) similar to those described in the paying-out gear. N and O are fleeting knives for keeping the space on the drum clear for each successive turn, the one N being used when picking up, and O when paying out.

A rotometer similar to the one used for the paying-out gear is affixed to the shaft of the drum to show the amount of grapnelling rope payed out, or cable picked up.

Although for clearness of delineation the various parts of the machinery are not arranged in the drawing exactly as erected on the ship, yet substantially it gives a correct idea of the picking-up gear of the *Sherard Osborne*, which was originally arranged in this form by Mr. Johnson when in the service of the Telegraph Construction and Maintenance Company. In some of the old machines, it may be added, the motion was imparted from the driving shaft to the shaft H by means of friction wheels instead of the cog-wheels I and G, and the draw-off motion was driven by a band instead of the bevel wheels as shown. In both cases, however, the objection to these plans was that they, owing to slip, did not given such powerful and steady results as have been obtained by the arrangement now used.

In picking up cable after it has been hooked by the grapnel and brought to the bows by the grapnelling rope, the bight is cut, and the end which it is decided to pick up is passed over the bow sheave P, under the wheel R of the dynometer S, over the drum A, around which several turns are taken, then over the wheel K of the draw off motion, and under the jockey wheel L, which, by its weight T, grips the cable and keeps a strain on it so that the turns grip tightly around the drum, the fleeting knife N making room for each fresh turn. The fleeting knife O, which is on the other side of the drum, is used when paying out the grapnelling rope. If the water is moderately deep the fast motion is used by connecting the shaft H with the wheel F, which gears into the wheel C on the drum shaft D. Should, however, the water be of considerable depth, the slow but more powerful purchase is used by connecting the shaft H with the small wheel G, which gears into the large wheel B. The cable is then taken from the draw-off motion, and coiled into the tank until the end or the fault be reached.

The laying of cables, even in deep water, has been rendered comparatively easy by the forethought, long practical experience, and perfect machinery possessed by the well-trained staff of the old cable manufacturing firms. But, although as much energy has been exercised in the branch of recovering and repairing cables, yet from the nature of the operations the latter is much the more difficult task.

In the first place, the laying is not so much dependent upon the weather—indeed, cables can be laid successfully during such states of wind and sea as would render recovery impossible.

In the second place, the difficulties that occur in laying can be better provided against and are more under the control of the engineer.

If we could secure a depth of 500 fathoms along the line of our cables, repairs could be executed with something like the certainty of laying; for both shallow and deep water present their difficulties. In shallow water, by way of example, one may day after day drag over a rocky or coral bottom with no other results than breaking grapnels and ropes, the grapnel no doubt often missing the cable by jumping over it in freeing itself from a rock. Again, when one has succeeded in hooking the cable, it is often broken before it reaches the bows or in picking up, either from its being overlaid by a growth of coral or shells, or by getting foul of a rock from which it is impossible to clear it by the most skilful manœuvring of the ship. But, on good bottom, which generally exists at 500 or 600 fathoms, the picking up would be easy in fairly fine weather.

When one comes to great depths, such as 1,000 to 2,000 fathoms, other difficulties present themselves. Although the bottom at these depths is generally good, and there is not much difficulty in hooking, yet the cable has to bear a great and increasing strain for hours, and bringing it to the bows of the ship is an operation of the greatest delicacy, requiring much more skill in manœuvring the ship and machinery than in paying out.

The finest weather is necessary, as with anything like a breeze it is extremely difficult to keep the ship in position, and the sea swell is very likely to snap the cable by bringing sudden strains on it.

There are few, if any, operations in mechanical engineering more trying than lifting cables in great depths. The anxious strain on the mind caused by watching every variation of the dynamometer hour after hour as the cable comes slowly from the bottom; the knowledge that the cable may be held by the bight being possibly over only one of the prongs of the grapnel, and that its slipping at any moment is an extremely probable contingency; in short, the uncertainty of the whole operation and the

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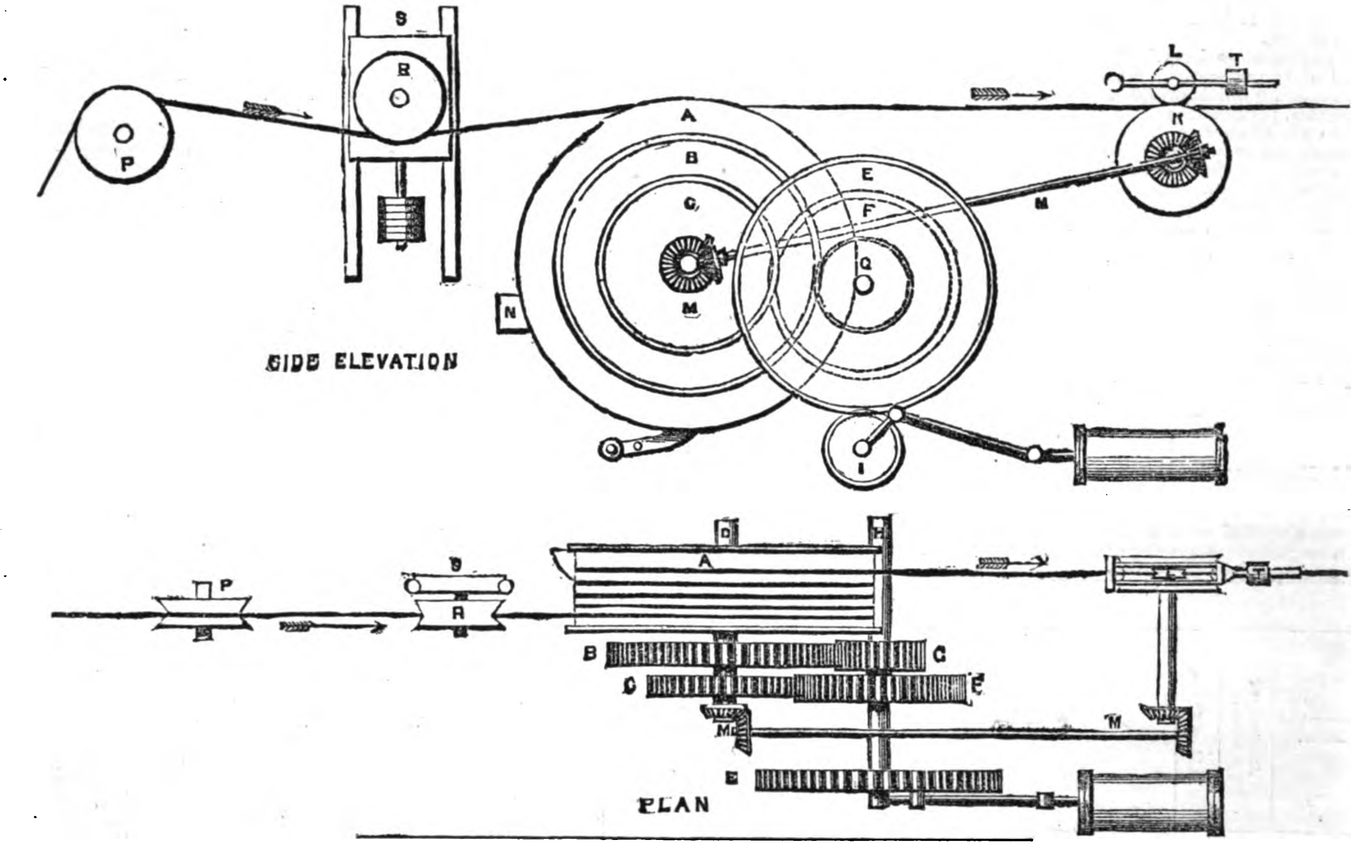
consequent impossibility to conclude even in one's own mind whether the work and the strain on one's energies will have to be repeated *de novo* again and again, form altogether, as said, a most trying feature in submarine telegraph engineering. Naturally, it is impossible to lift the bight of the cable to the surface from depths of the nature spoken of without breaking it, and as a consequence various means have been used to insure the break taking place on the right side. Of these may be mentioned, lifting the cable a certain distance, buoying the bight, and then going farther along and lifting again until the cable is gradually brought to the surface; or by one ship hooking with the grapnel intended to bring the cable to the surface, and another ship, some distance off, hooking nearer the end with a cutting grapnel, and thus making a short end for the ship which is to lift the cable. Again, grapnels have been used which are both cutting and holding appliances, so that after the strain reaches a certain amount the cable not wanted is cut off, and the end intended to be brought to the surface is firmly grasped. But enough has now been said to enable the reader to follow, roughly, in his mind's eye, some of the difficulties of laying and picking up cables, and it is much to be hoped that we shall very shortly hear of the successful completion of the repairs of the Atlantic cables by one of the plans just sketched, as has been the case in other operations of a like nature.

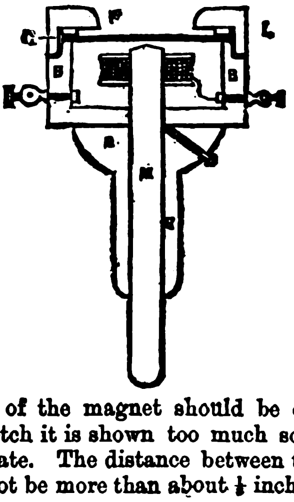


A CHEAP TELEPHONE.

BY W. J. WILSON, F.C.S., M.S.T.E.

The materials required are :—A piece of round steel $\frac{3}{8}$in. diameter, 3$\frac{1}{2}$in. long, or a piece of an old round file about this size, a piece of stout card, $\frac{1}{4}$oz. of No. 36 silk-covered copper wire, two small binding-screws, a round-headed brass wood-screw $\frac{3}{4}$in. long, a ferrotype iron or thin tin-plate disc, a round wooden tooth-powder box about 2in. diameter, and a large empty cotton reel. File one end of the steel to a very blunt cone and round the other end. Make it bright red hot in a good fire, then plunge it into cold water, moving it about until cold. Magnetise it as strongly as possible: shop made magnets are seldom either hard or strong enough. Cut two discs of card each the size of a halfpenny and cut a $\frac{3}{8}$in. hole in the centre of each. Glue one of them on the magnet close to the conical end; glue the other on $\frac{1}{4}$in. distant from the first. When the glue is hard wind the wire on the magnet in the space between the cardboard discs, leaving 6in. of each end free. Cut off one end of the cotton reel and glue the other end on the bottom of the box. Continue the hole in the reel through the bottom of the box, and enlarge it with a bit, file, or red hot poker, until the magnet just passes through easily. Fix the binding screws through the side of the box opposite to each other, and solder the ends of the wire to them. Screw the brass screw through the thick part of the cotton reel so that it may pinch the magnet when the latter is in its place. Slip the magnet into its place, the bobbin of wire being within the wood box. Lay a straight edge across the top of the box, and shift the magnet until its end is about 1-20 of an inch from the straight edge; then fix the magnet by screwing up the pinching screw. Cut a round hole an inch diameter in the lid of the box, round the outer edge. Cut a disc of carboard to just fit inside the lid, then cut out middle so as to leave only a ring of card $\frac{1}{8}$in. broad: the use of this ring is to ensure a space between the inside of the lid and the ferrotype plate. Cut the latter so that it rests on the edge of the box, and allows the lid to fit on over it. The lid usually fits tightly enough without any further fastening; if it should not do so it may be glued on, but it is preferable to be able to take it off at any time. The above description is perhaps rather too brief to be very intelligible, but the sectional sketch will, I think, make all clear. M is the magnet, R the cotton reel, B B the box, P the ferrotype plate, L L the lid, c the cardboard ring.

As to the efficiency of these instruments, I have heard not a few telephones of one sort or another during the last nine months, but I can honestly say that I have heard few to beat these; as regards distinctness, I am not sure that I have heard any to equal them.



NOTE.—The end of the magnet should be only very slightly conical; in the sketch it is shown too much so, and the bobbin too far from the plate. The distance between the plate and card of bobbin should not be more than about $\frac{1}{8}$ inch.

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THE EASTERN TELEGRAPH COMPANY (LIMITED).

We extract the following from the report of the directors to the twelfth ordinary general meeting :—

"The directors submit the accounts and balance sheet for the six months ended 31st March, 1878.

"The company's revenue for this period amounted to 238,114*l*. 15s. 11d., from which is deducted 58,101*l*. 14s. 3d., the ordinary expenses of the company, and 26,179*l*. 17s. special expenditure during the half-year, 602*l*. 6s. 10d. for bad debts, and 1,501*l*. 1s. 9d. by income-tax, leaving 151,729*l*. 16s. 1d., which, together with 12,779*l*. 6s. 2d. brought forward from the preceding half-year, gives a balance of 164,509*l*. 2s. 3d. From this balance 11,810*l*. 10s. is payable for interest on debentures, and 20,737*l*. 17s. 10d. for dividend to 31st March, 1878, at 6 per cent. per annum on the preference shares.

"The directors have during the half-year paid an interim quarterly dividend of 1¼ per cent. on the ordinary shares. They now recommend the declaration of a final dividend for the year ended 31st March, 1878, of 2s. 6d. per share, payable 15th July next, making, with the three previous payments on account, a total dividend for the year of 5 per cent. on the ordinary shares, and that the balance, 39,535*l*. 14s. 5d., be carried to the reserve fund, which will then amount to 152,198*l*. 5s. 5d.

"The several sections of the company's cables are in good working order.

"The cable repairing ships stationed in the Mediterranean and Red Sea remain in efficient condition, and in readiness for the company's requirements.

"The directors have made arrangements with Her Majesty's Government and the Government of H.I.M. the Sultan for the extension of this company's Levant system of cables to Constantinople. Several sections have already been laid by the company's ships; and the other connections are in progress. Part of the cost of these works has been paid by Her Majesty's Government, and the directors expect to provide the balance without any fresh issue of capital of the company."

RECENT PATENTS.

3822. ELECTRIC TELEPHONY AND TELEGRAPHY, *by D. D. Redmond.—Dated October* 16, 1877. (*Not proceeded with.*) 2*d*.

In telephones hitherto constructed the sound wave has been converted into an electrical wave by means of a vibrating diaphragm, either acting on a magnet or interposing a variable resistance in the circuit. This method proposes to convert the sound wave into an electrical wave by means of a thermopile. The sound wave having a period of compression and expansion renders sensible a varying amount of heat, as we know from the familiar experiment of lighting a piece of tinder by compressing gas in a syringe, that when the density of a body is increased a certain amount of heat is emitted. This heat, falling on the pile, creates an electrical wave which is sent along the line wire and reconverted into a sound wave either by means of an electro-magnet and vibrating diaphragm, or electro-magnet alone, or by a second thermopile, after the manner of the experiment known as Peltier's cross. The face of the thermopile at both or either ends may or may not have a vibrating diaphragm interposed to take up or emit the vibrations to the air; between this diaphragm and the face of the pile different bodies may be interposed, which, by their compression, increase the amount of heat generated by the sound wave; or the faces may be simply coated with substances which cause the sound wave to yield more heat; or the wave may be amplified by dancing flames.

3981. ELECTRIC MAGNETS, AND MAGNETIC MOTOR ENGINES, *M. H. Smith.—Dated 27th October*, 1877. 6*d*.

The magnet consists of a coil of copper wire resting upon an iron base plate, and surrounded by an iron case attached to the base plate. The armature consists of an iron plate, the size of the case, and an iron core fitting and sliding into the copper coil, so that when the core touches the base plate the armature disc touches the top of the case. The motor engine comprises a set of magnets arranged at distances apart and forming a circle, above which is a disc resting on a pivot; the outer edge of the disc forms the armatures above the circle of the magnets. The disc being tilted, one portion of its periphery approaches one or other of the magnets.

4275. PRODUCING ELECTRIC LIGHT, *F. W. Heinke.—Dated* 15*th November*, 1877.—(*Not proceeded with.*) 2*d*.

Two discs of carbon or other suitable substance are placed opposite one another in the same plane, and caused to revole. The discs are enclosed in a glass or metal case, provided with apertures at the top and bottom. The heat caused by the combustion of the carbon when the circuit is completed causes a strong draught or current of air to enter at the lower apertures and to pass off at the upper aperture. This current is applied to turn a fan, which by suitable intermediate gears gives motion to the carbons, and works the feed by means of a worm and worm-wheel, or other suitable gear, so that the carbons are always kept at the desired distance apart in proportion as they burn away.

TELEGRAPH SHARE LIST.

Amount of Issue.	Amount of Share.	Paid on Share.	COMPANY.	Reserve as per last Report.	Dividends calculated at rate per cent. per annum. 1875. %	1875. %	1876. %	1876. %	1877. %	1877. %	When Payable.	PRICES. 1875. Highest.	1875. Lowest.	1876. Highest.	1876. Lowest.	1877. Highest.	1877. Lowest.
£3,254,580	Stock	100	PAnglo-American	Deferred receiving no dividend until 6 per cent. has been paid to Preferred.		year.	5	4†	3	5	† Div. 5 % per ann. for quarter ending Dec. 31, 1876, 2% for quarter ending Mar. 31, 4 % for quarters ending June 30 and Sept. 30, 6 % for quarter ending Dec. 31, 1877, and 4 % for quarter ending March 31, 1878.	75½	51½	68½	53	62¼	52
1,872,710	Stock	100	Do. Preferred B		—	—	10	2	6	6		Crtd	1876.	93	75	88½	79
1,872,710	Stock	100	Do. Deferred A		—	—	Nil.	6	Nil.	4		Crtd	1876.	44	29	38	25½
1,300,000	10	All	Brazilian Submarine	120,000	5	5	5	5	5	5	Quarterly.	7¾	6	7¾	5¾	6¾	5⅞
160,000	10	All	Cuba (Limited)	—	—	—	—	—	—	—	——	—	—	—	—	—	—
60,000	10	All	Do. 10 per cent. Preference	—	—	—	—	—	—	—	——	—	—	—	—	—	—
116,379	10	9	Direct Spanish (Limited)	—	—	—	—	—	—	—	——	—	—	—	—	—	—
58,430	10	All	Do. 10 per cent. Preference	—	—	—	—	—	—	—	——	—	—	—	—	—	—
65,000	20	All	Direct United States	Nil.	—	Nil.	Nil.	Nil.	Nil.	5	Quarterly.	13	7	11½	6¼	13¾	9½
369,700	10	All	Eastern (Limited)	110,000	5	year.	5	5	5		*a*Jany., April, *July*, Oct.	8	6⅜	7⅛	5	8¼	6⅝
232,000	100	All	Eastern 6 per cent. Debentures	—	—	—	—	—	—	—	——	—	—	—	—	—	—
200,000	100	All	Do. 5 per cent. Debentures	—	—	—	—	—	—	—	——	—	—	—	—	—	—
700,000	10	All	Do. 6 per cent. Preference	—	—	—	—	—	—	—	——	—	—	—	—	—	—
1,997,500	10	All	Eastn. Exten. Australasia & China	125,404	5½	year.	5	year.	5	year.	*a*Jany., *April*, July, Oct.	8¼	7	7½	5½	8	6⅞
320,000	100	All	Eastn. Exten. 6 p.c. Deben. (1875)	—	—	—	—	—	—	—	——	—	—	—	—	—	—
192,680	10	All	German Un. Tl. and Tst.	—	—	—	—	—	—	—	——	—	—	—	—	—	—
1,500,000	10	All	Globe Telegraph and Trust	Nil.	5	7 4–5	4⅓	7 5–6	3⅜	7 6–7	*b*Jany., April, *July*, Oct.	6¾	5⅛	5⅞	4¼	5¼	4½
1,500,000	10	All	Do. 6 per cent. Preference		6	6	6	6	6	6	Jany., April, July, Oct.	10½	9¾	10⅛	9¼	10½	9½
150,000	10	All	Great Northern Shares to Bearer, or can be Regstrd.	85,543	5⅝	year.	6⅜	year.	6⅜	year.	5 % intrm. Jan. 1, July 1. Final Dividend April.	11½	7½	9¾	7	8	7
—	25	All	Indo-European	—	—	—	—	—	—	—	——	—	—	—	—	—	—
120,000	10	All	Mediterranean Extension (Lmtd.)	—	—	—	—	—	—	—	——	—	—	—	—	—	—
32,000	10	All	Do. 8 per cent. Preference	—	—	—	—	—	—	—	——	—	—	—	—	—	—
—	18	All	Reuter's (Limited)	—	—	—	—	—	—	—	——	—	—	—	—	—	—
65,000	10	All	West India and Panama	16,000	Nil.	Nil.	Nil.	Nil.	1	1	‡ Converted from a 10 % into a 6 % 1st Preference.	4¾	1⅝	2½	⅝	3⅝	1⅝
34,563	10	All	Do. 6 per cent. Preference		7/6ac	year.	10/ac	year.	6‡	6		12	9	11	7	11	7½
67,500	20	All	Western and Brazilian	7,793	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Half-yearly.	18¼	9½	10⅝	4½	5¾	4½
$1,500,000	$1000	All	Western Union Telegraph 7 per cent. First Mortgage Bonds	—	7	7	7	7	7	7	May, November.	108	102½	109¼	105	113	106
£1,030,000	200	All	Do. 6 per cent. Sterling Bonds	Redeemable by annual drawings at par.	6	6	6	6	6	6	March 1, September 1.	93	83	93	89	101	94

a Year ends March 31st. Interim Dividend of 5 per cent. Final dividend in July.

b Year ends July 18th. Final dividend in July.

COMPANIES.	BUSINESS DONE. Th., 27.	F., 28.	Sat., 29.	Mon., 1.	Tu., 2.	Wed., 3.
Anglo-American (1)	acc. 65⅛, 5	—	64⅛, ⅛	64⅜	—	64⅛, ⅛
Do. Preferred	—	93⅛, ⅛ ⅛	—	93⅜	93⅜	93⅛
Do. Deferred (a)	acc. 38	38⅛, 38	—	37⅜	—	37⅛
Brazilian Submarine	acc. 7⅛	—	—	7 x.d.	6⅜ x.d.	—
Eastern (Limited)	7⅜	7⅜, ⅞	7 13-16, ⅞	7 13-16	7 11-16 13-16	7⅝
Do. 6 p. c. Prefrnce.	—	11⅛, ⅞	—	11⅞	—	12
Eastern Extension, Austral., & China (1)	—	7⅞	—	7 13-16, ⅞ 15-16	—	—
Do. 6 p. c. Deb. 1875.	—	109½	—	—	—	—

COMPANIES.	BUSINESS DONE. Th., 27.	F., 28.	Sat., 29.	Mon., 1.	Tu., 2.	Wed., 3.
Drct. U. S. Cable (1)	14½ ⅝	14⅜	—	—	—	14½, ⅝
German Un. Tl. and Tst.	—	—	—	—	—	8½
Globe Tl. & Trst. (1)	5½, acc. 5⅜	5½	5 9-16, ⅜ 9-16	5½	5½	5 9-16
Do. 6. p. c. Prefrnce.	acc. 11½	11½	11½	11½	—	11½
Great Northern	—	—	8⅜, x.d.	—	8⅜, x.d.	8⅜
Mediterranean Ex. (1.)	—	—	—	2⅞	2 13-16	—
W. India & Pan. (1)	—	2 9-16	—	2⅝	—	2½
Do. 6 p. c. 1st Prefnc.	—	—	—	8⅞	8⅞ 13-16	—
Do. 2nd Preference	—	8½	—	—	8½	8 13-16

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NOTES.

CABLE LAYING.—The telegraph cable between Tenedos and Constantinople has been successfully laid.

THE EASTERN TELEGRAPH COMPANY.—The company's traffic receipts for the month of June, 1878, amounted to 31,118*l.* and to 45,477*l.* in the corresponding period of 1877.

TELEGRAPH CONSTRUCTION AND MAINTENANCE.—The company will pay an interim dividend of 12s. per share, being the same as that paid at this time last year.

SCIENCE AND INDUSTRY.—Another exhibition is already announced for 1879 at the Palais de l'Industrie. It is happily only on a small scale, and will form a mere corollary to the World's Grand Fair of the present year. It is to be called the Exhibition of Sciences applied to Industry.

THE GREAT NORTHERN.—"Advices having been received that the company's Amoy-Shanghai cable is interrupted, messages for Hongkong and Amoy (Foochow) cannot be accepted." During the interruption the company's line is the only telegraph route to Shanghai and to all stations in Japan.

THE CUBA SUBMARINE COMPANY.—Information has been received by the Cuba Submarine Telegraph Company of the repair of one of the cables belonging to the International Ocean Telegraph Company between Havana and Key West, whereby telegraphic communication with the West Indies, Panama, and Demerara is restored.

WESTERN UNION TELEGRAPH COMPANY.—At the quarterly meeting of the directors of this company, held June 12th, a dividend of 1½ per cent. on the outstanding capital stock of the company was declared from the net profits of the quarter ending June 30th, 1878, payable July 15th. Stock books closed from June 20th to July 16th.—*Journal of the Telegraph, U.S.A.*

ANGLO-AMERICAN.—At a meeting of the board of directors of the Anglo-American Telegraph Company (Limited) held July 5th it was resolved, after reserving 37,500*l.* for the renewal fund, to declare an interim dividend for the quarter ending the 30th of June of 1 per cent. on the consolidated stock, and of 2 per cent. on the preferred stock, both free of income-tax, payable on the 1st August to the shareholders registered on the 1st July, leaving a balance of about 14,000*l.* to be carried to next quarter's account.

THE TELEPHONE IN TELEGRAPHY.—The *Engineering and Mining Journal* says that Mr. Edison has made a contract with the Western Union Telegraph Company by which all his electrical and magnetic inventions become the property of the company. These include his telephone, which the company considers the most useful telephone invented. The company hopes to establish telephone communication with at least 4,000 towns too small to support the expenses of a telegraph operator. Partial confirmation of the above statement may be found by reference to the official list of patents where many of Mr. Edison's patented improvements may be found assigned to the Western Union Telegraph Company.

TELEPHONIC EXPERIMENTS.—When to a vibrating membrane is attached a coil of wire loosely surrounding the pole of a magnet, a current is induced in the coil at each vibration. It is obvious that these currents, when passed through a second coil similarly attached to a membrane in proximity to a magnet, may be made to reproduce the original vibrations. This arrangement, which is due to Mr. Desmond Fitz-Gerald, has, however, been found by him to be singularly ineffective in comparison with that of Elisha Gray and Graham Bell. The experiments made with it strengthen the conclusion that the efficacy of Bell's Telephone is dependent upon its magnetic diaphragm, the molecular vibrations of which cannot advantageously be superseded by the simple vibration of a mass.

THE ELECTRIC LIGHT.—Information is now reaching us almost daily of contemplated experiments by public authorities in various parts of the country in regard to the electric light; and we have good reason for anticipating that before long the combined experience and knowledge of the scientific gentlemen under whose supervision these inquiries and trials are to be made will produce very satisfactory and very practical results. The Metropolitan Board of Works have the question under consideration; and the Chelsea Vestry, in view of the continued complaints with regard to the gas supplied to the parish, have also instructed their surveyor, Mr. G. H. Stayton, to report fully on the whole subject, with permission to visit Paris, in order to inspect the system now in use in the French capital.

WHO INVENTED THE MUSICAL TELEPHONE?—The *Scientific American* of March 9 says:—"Evidence is at hand showing that the telephone was invented many years ago and forgotten. It is generally supposed that Reiss, in 1861, was the first to use vibrating membranes or thin plates. Professor Sigismund Beer sends us an acccount of a 'new musical instrument,' which he finds in the *Berliner Musik Zeitung Echo*, No. 33, *Dingler's Journal*, vol. 126, both for the year 1852; and 'Böttger's Polytechnisches Notizblatt, for 1853.' The inventor is M. Petrina, of Prague, who is stated to have constructed 'an instrument with keys, which by a galvanic current sets a small iron plate into vibration as soon as the hand leaves the key. Each key produces a different tone, and the tuning and use are similar to that of a pianoforte. A second instrument, put at a considerable distance, is connected with the other in such a way that the music played on the one resounds from the other.' This appears to be a musical telephone put in practical form long before any now known."

THE EFFECT OF LIGHT ON THE CONDUCTIVITY OF SELENIUM.—Mr. Sabine, in the paper we last week referred to, gives the following experiments which he made to determine whether the effect of light upon a plate of selenium when in a galvanic circuit, in increasing the current, is due to a photo-electromotive force in the same direction as the battery current, or to a decrement of resistance. Let the resistance between the wires of the selenium plate in the dark and of the galvanometer be r, the electromotive force of the measuring battery be E, and the observed current c. On admitting light the current increases to c', and one of two things must have happened. Either (1) the increment of current is due to the decrement (x) of resistance, in which case

$$c = \frac{E}{r} \text{ has changed to } c' = \frac{E}{r - x},$$

$$x = E\frac{c' - c}{c\,c'}; \quad . \quad . \quad . \quad \text{(I.)}$$

or (2) the increment of current is due to a photo-electromotive force (y) in the selenium, in which case

$$c = \frac{E}{r} \text{ has changed to } c' = \frac{E + y}{r},$$

$$y = E\frac{c' - c}{c}. \quad . \quad . \quad . \quad \text{(II.)}$$

With a single measurement it is, of course, impossible to dis-

criminate between the two cases; but, by a known augmentation of battery and of resistance, it is easy to find which supposition affords the better agreement. I increased E to 2E, and inserted a known resistance (r_1) as nearly equal to r as I could make it. The resulting current, when the selenium was in the dark, was c_1; and it increased to c_2 when subjected to the same source of light as before. Then either

$$c_1 = \frac{2E}{r + r_1} \text{ changes to } c_2 = \frac{2E}{r + r_1 - x},$$

$$x = 2E\frac{c_2 - c_1}{c_2 c_1}; \quad . \quad . \quad . \quad \text{(III.)}$$

$$\text{or } c_1 \text{ changes to } c_2 = \frac{2E + y}{r + r_1}, \; y = 2E\frac{c_2 - c_1}{c_1}. \quad . \quad \text{(IV.)}$$

It is plain that, if the values of x calculated by (I.) and (III.) agree better than those of y calculated by (II.) and (IV.), the change must be due to resistance. The battery consisted of twelve similar Daniell's cells of large surface. They were connected with a commutator, by which, with a single movement, they could be connected up either in series or six and six parallel. In this way, by using the same elements in each measurement, the effect of any slight accidental difference in their electromotive forces would be, to a great extent, neutralised. No difference could be observed by the discharge of an accumulator, and therefore I assume they were in every respect equal. The currents were measured by means of a reflecting galvanometer. A selenium plate with six elements in the dark gave a current $c = 0·498$ microweber. When the battery was doubled and the constant resistance r_1 added, the current observed was $c_1 = 0·508$ microweber. Diffused daylight admitted to the selenium, with the six double surface elements the current increased to $c' = 0·860$ microveber; with the twelve elements in series and resistance r_1 the current was $c_2 = 0·643$ microveber. Putting E = 6·72 volts, the value of x and y, calculated from the above data, are as follows:—

x		y	
I.	III.	II.	IV.
3·68 meg.	5·56 meg.	4·89 volts.	3·57 volts.

Similar measurements were made with two other plates, which gave the following results:—

x		y	
I.	III.	II.	IV.
6·39 meg.	6·43 meg.	5·76 volts.	3·86 volts.
55·2 „	53·0 „	0·75 „	0·53 „

It appears from the above that the agreement between the calculated values representing the change, on the supposition that it is due to a decrement of resistance, is much greater than that between the values calculated on the supposition that it is due to an electromotive force set up in the selenium in the same direction as the battery current.

Thunderstorms.—We have experienced this year a succession of extraordinary thunderstorms, accompanied by an excessive downpour of rain. Had our telegraphic society been duly organised, the opportunity of a fairly thorough investigation of these phenomena would not have been lost. We would humbly suggest to the Society of Telegraph Engineers that sub-committees of investigation should be formed to carry out experiments and record observations upon various phenomena connected with electrical subjects. The late Professor Henry suggested to the American Electrical Society that it should collect and preserve information relating to thunder storms, and also prepared a series of questions as a contribution towards a more complete series to direct attention to special points of inquiry. These questions may prove useful in scientific investigations, and we therefore append them to this note. *Particulars of the Storm:*—*(i.)* Give the number and time of occurrence of thunder storms, so as to show their distribution through the months, days, and hours of the year. *(ii.)* Note the point of the horizon in which the storm generally arises in any given locality, and the point to which it tends. *(iii.)* Observe whether it usually divides into two storms at any point; if so, what is the topography of the surface below? *(iv.)* Determine the width of the storm from the extent of the surface covered by rain, and also, if possible, by means of the telegraph, the length of its path. *(v.)* Note the condition of the air before and after the storm, as to temperature, moisture, and pressure; also the temperature of the water which falls. *(vi.)* Give the direction of the wind previous to the beginning of the storm, during its continuance, and after its ending. *(vii.)* Observe whether a calm precedes the violent part of the storm, and whether in front of it a curtain of dust is raised to a considerable height in the air. *(viii.)* Note the number of seconds the sound of a discharge continues, which will give approximately the minimum length of its path. *(ix.)* Note the time between the appearance of the flash and the hearing of the thunder, and also the angle of elevation; these will give approximately the height of the cloud. *(x.)* Ascertain whether any hail accompanies the storm; if it does not, whether it falls along in two tracks, or in one. In the former case, give the distance between the tracks. Give the size and character of the hail, whether it consists of an agglomeration of crystal, or of rounded masses stratified with clear ice and snowy concretions, and whether it contains in some cases small particles of dust or sand. *(xi.)* Note the number of discharges between the different parts of the same or different clouds, and also between the cloud and the earth. The former will probably be more frequent than the latter. *(xii.)* Note the colour of the lightning, particularly if it be violet, which will probably indicate a cloud of great elevation. *B. Effects of the Electric Discharge:*—*(i.)* State what kind of trees are struck, and on what parts of the tree the effects are most apparent—on the branches, or the trunk. *(ii.)* What are the mechanical effects observed in the tree; is it torn asunder laterally, or is it broken transversely to the axis, or both. *(iii.)* Was the tree green or dry? *(iv.)* When a house is struck, state if it had a lightning-rod, and, if so, give its character and especially its connection with the ground. *(v.)* Mention the part of the house struck; if the chimney, was there fire in it at the time? Give the path of the discharge through the house, and its relation to conducting metals? *(vi.)* Note the inductive effects of the discharge in producing sparks and flashes between different objects within the premises. *(vii.)* If the discharge passes through metallic conductors and disintegrate them, note any appearance which might tend to indicate whether the effect is produced by heat or by repulsive energy imparted to the atoms at the moment of the discharge. *(viii.)* If the discharge takes place between two surfaces, note if there is any apparent transfer of material from one to the other. *(ix.)* Note any peculiarity of odour that may be observed. All mechanical effects produced by the discharge should be mentioned, and notes should be made as to whether they are not in most cases produced by a violent repulsive energy given to the air in the path of the discharge, and whether the effects are greater in the direction of the axis of the discharge than in that at right angles to the same. *(x.)* Note the effect upon man and animals; whether a part of the discharge passed through the body, or whether inductive shocks were felt.

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THE ABSOLUTE UNIT OF ELECTRICAL RESISTANCE.

BY PROFESSOR H. A. ROWLAND.

[CONTINUED FROM P. 51.]

When a current is induced in a circuit by magnetic action of any kind, Faraday has shown that the induced current is proportional to the number of lines of force cut by the circuit and inversely as the resistance of the circuit. If we have two circuits near each other, the first of which carries a current, and the second is then removed to an infinite distance, there will be a current in it proportional to the number of lines of force cut. Let, now, a unit current be sent through the second circuit and one of strength E through the first; then, on removing the second circuit, work will be performed which we easily see is also proportional to the number of lines of force cut. Hence, if E M is the work done, Q is the induced current, and R is the resistance of the second circuit, $Q = C\,E\,\frac{M'}{R}$ where C is a constant whose value is unity on the absolute system.

When the current in the first circuit is broken, the lines of force contract on themselves, and the induced current is the same as if the second circuit had been removed to an infinite distance. If the current is reversed, the induced current is twice as great; hence in this case $Q = 2\,E\,\frac{M}{R}$, or $R = 2\,M\,\frac{E}{Q}$.

Hence, to measure the absolute resistance of a circuit on this method, we must calculate M and measure the ratio of Q to E, M is known as the mutual potential of the two circuits with unit currents, and mathematical methods are known for its calculation.

The simplest and best form in which the wire can be wound for the calculation of M is in parallel circular coils of equal size and of as small sectional area as possible. For measuring E a tangent galvanometer is needed, and we shall then have $E = \frac{H}{G}\tan.\,\theta$ where H is the horizontal intensity of the earth's magnetism at the place of the tangent galvanometer and G the constant of the galvanometer. For measuring Q we must use the ballistic method, and we have

$$Q = \frac{H'}{G'}\,\frac{T}{\sqrt{\pi^2+\lambda^2}}\,E^{\frac{\lambda}{\pi}\tan.^{-1}\frac{\pi}{\lambda}}\,2\sin.\tfrac{1}{2}\theta',$$

which, for very small values of λ, becomes

$$Q = \frac{H'}{G'}\,\frac{T}{\pi}\,2\sin.\tfrac{1}{2}\theta'\left(1+\tfrac{1}{2}\lambda-\frac{1}{6}\lambda^2\right)$$

$$\therefore R = M\frac{H}{G'}\,\frac{G'}{G}\,\frac{\pi\tan.\,\theta}{T\sin.\frac{1}{2}\theta'}\,\frac{1}{1+\frac{1}{2}\lambda-\frac{1}{6}\lambda^2}$$

where H' is the horizontal component of the earth's magnetism at the place of the small galvanometer, G' its constant, T the time of vibration of the needle, and λ the logarithmic decrement.

The ratio of H' to H can be determined by allowing a needle to vibrate in the two positions. But this introduces error, and by the following method we can eliminate both this and the distance of the mirror from the scale by which we find θ', and the error of tangent galvanometer due to length of needle. The method merely consists in placing a circle around the small galvanometer, and then taking simultaneous readings with the current passing through it and the tangent galvanometer before and after each experiment. Let a and a' be the deflections of the tangent galvanometer and the other galvanometer respectively, and let G'' be the constant of the circle at the point where the needle hangs, then: $\frac{H}{G}\tan.\,a = \frac{H'}{G''}\tan.\,a'$, and we have finally

$$R = M\frac{\pi}{T}\,\frac{G}{G''}\,\frac{\tan.\,a'}{\tan.\,a}\,\frac{\tan.\,\theta}{\sin.\frac{1}{2}\theta'}\,\frac{1}{1+\frac{1}{2}\lambda-\frac{1}{6}\lambda^2},$$

which does not contain H or H,' and the distance of the mirror from the scale does not enter, except as a correction in the ratio of sin ½ θ' and tan a'; and, as a and θ can be made nearly equal, the correction of the tangent galvanometer for the length of needle is almost eliminated. When the method of recoil is used we must substitute $\frac{1}{1+\frac{1}{2}\left(\frac{\lambda}{\pi}\right)}$ for the term involving λ, and sin. ½ A' + sin. ½ B' in the place of sin. ½ θ', A' and B' being the greater and smaller arcs in that method. This is on the supposition that λ is small.

The ratio of G'' to G must be so large—say 12,000—that it is difficult to determine it by direct experiment, but it is found readily by measurement or indirect comparison.

It is seen that in this equation the quantities only enter as the first powers, and that the only constants to be determined which enter the equation are M, G, and G," which all vary in simple proportion to the linear measurement. It is to be noted, also, that the only quantities which require to be reduced to standard measure are M and T, and that the others may all be made on any arbitrary scale. No correction is needed for temperature except to M. Indeed, I believe that this method exceeds all others in simplicity and probable accuracy and in its freedom from constant errors, seeing that every quantity was varied, except G'' and G, whose ratio was determined within probably one in three thousand by two methods.

Having obtained the resistance of the circuit by this method, we have next to measure it in ohms. For this purpose the resistance of the circuit was always adjusted until it was equal to a certain German silver standard, which was afterwards carefully compared with the ohm. This standard was about thirty-five ohms.

By this method the following data are needed:—

1. Ratio of constants of galvanometer and circle.
2. Ratio of the tangents of the two deflections of tangent galvanometer.
3. Ratio of the deflection to the swing of the other galvanometer.
4. Mutual potential of induction coils on each other.
5. Time of vibration of the needle.
6. Resistance of standard in ohms.

For correction we need the following:—

1. The logarithmic decrement.
2. Distance of mirror from scale.
3. Co-efficient of torsison of suspending fibre.
4. Rate of chronometer.
5. Correction to reduce to standard metre.
6. Variation of the resistance of German silver with the temperature.
7. Temperature of standard resistance.
8. Arc of swing when the time of vibration is determined.
9. Length of needle in tangent and other galvanometer (nearly compensated by the method).
10. The variation of resistance of circuit during the experiment.

The following errors are compensated by the method of experiment:—

1. The local and daily variation of the earth's magnetism.
2. The variation of the magnetism of the needle.
3. The magnetic and inductive action of the parts of the apparatus on each other.
4. The correction for length of needle in the tangent galvanometer (nearly).
5. The axial displacement of the wires in the coils for induction.
6. The error due to not having the coils of the galvanometer and the circle parallel to the needle.
7. Scale error (partly).
8. The zero error of galvanometers.

Calculation of Constants.

Circle.—For obtaining the ratio of G to G'', it is best to calculate them separately and then take their ratio, though it might be found by Maxwell's method. ("Electricity," Article 753.) But, as the ratio is great, the heating of the resistances would produce error in this latter method. For the simple circle

$$G'' = 2\pi\frac{A^2}{(A^2+B^2)^{\frac{3}{2}}} = \frac{2\pi}{A}\left(1-\frac{3}{2}\left(\frac{B}{A}\right)^2+\&c.\right)$$

where A is its radius and B the distance of the plane of the circle to the needle on its axis.

Galvanometer for Induction Current.—For the more sensitive galvanometer, we must first assume some form which will produce a nearly uniform field in its interior, without impairing its sensitiveness. If we make the galvanometer of two circular coils of rectangular section whose depth is to its width as 108 to 100, and whose centres of sections are at a radius apart from each other, we shall have Maxwell's modification of Helmholtz's arrangement. The constant can then be found by calculation or comparison with another coil.

Maxwell's formulæ are only adapted to coils of small section. Hence we must investigate a new formula.

Let N be the total number of windings in the galvanometer.

Let R and r be the outer and inner radii of the coils.

Let X and x be the distance of the planes of the edges of the coils from the centre.

Let a be the angle subtended by the radius of any winding at the centre.

Let b be the length of the radius vector drawn from the centre to the point where we measure the force.

Let θ be the angle between this line and the axis.

Let c be the distance from the centre to any winding.

Let w be the potential of the coil at the given point.

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Then (Maxwell's 'Electricity,' Art. 695) for one winding,

$$w = -2\pi\left\{1 - \cos. a + \sin.^2 a\left(\frac{b}{c}Q_1'(a)\,Q_1(\theta) + \frac{1}{2}\left(\frac{b}{c}\right)^2 Q_2'(a)\,Q_2(\theta) + \&c.\right)\right\}$$

and for two coils symmetrically placed on each side of the origin,

$$w = 4\pi\left\{\cos. a - \sin.^2 a\left(\frac{1}{2}\left(\frac{b}{c}\right)^2 Q_2'(a)\,Q_2(\theta) + \frac{1}{4}\left(\frac{b}{c}\right)^4 Q_4'(a)\,Q_4(\theta) + \&c.\right)\right\}$$

where $Q_2(\theta)$, $Q_4(\theta)$, &c., denote zonal spherical harmonics, and $Q_2'(a)$, $Q_4'(a)$, &c., denote the differential coefficients of spherical harmonics with respect to cos. a.

As the needle never makes a large angle with the plane of the coils, it will be sufficient to compute only the axial component of the force, which we shall call F. Let us make the first computation without substitution of the limits of integration, and then afterwards substitute these:

$$F = \frac{1}{2}\frac{N}{(R-r)(X-x)}\int\int\frac{dw}{dx}\,dx\,dr$$

$$F = \frac{1}{2}\frac{N}{(R-r)(X-x)}\int w\,dr,$$

and we can write

$$F = \frac{2\pi N}{(R-r)(X-x)}\left\{H_0 + H_2 b^2 Q_2(\theta) + H_4 b^4 Q_4 + \&c.\right\}$$

where $H_0 = x\log_\epsilon(r + \sqrt{x^2 + r^2})$

$$H_i = -\frac{1.3.5\,..\,(2i-1)}{i\,(1.2.3\,..\,i)}\frac{\sin.^3 a}{x^{i-1}}\left\{A_i\frac{\cos.^{2i-4} a}{2i-1} + B_i\frac{\cos^{2i-6}}{2i-3} + \&c.\right\}$$

$A_i = i,$

$$B_i = A_i\frac{2i-4}{2i-1} - \frac{i(i-1)(i-2)}{(2i-1)2},$$

$$C_i = B_i\frac{2i-6}{2i-3} + \frac{i(i-1)(i-2)\,..\,(i-4)}{(2i-1)(2i-3)2.4},$$

$$D_i = C_i\frac{2i-8}{2i-5} - \frac{i(i-1)\,..\,(i-6)}{(2i-1)(2i-3)(2i-5)2.4.6},$$

$E_i = \&c., \&c.$

Substituting the limits for x, r, and a, we find

$$H_0 = X\log_\epsilon\frac{R + \sqrt{X^2 + R^2}}{r + \sqrt{X^2 + r^2}} - x\log_\epsilon\frac{R + \sqrt{x^2 + R^2}}{r + \sqrt{x^2 + r^2}},$$

$$H_2 = -\frac{1}{2}\left\{\frac{1}{X}\left(\frac{R^3}{(R^2 + X^2)^{\frac{3}{2}}} - \frac{r^3}{(r^2 + X^2)^{\frac{3}{2}}}\right) - \frac{1}{x}\left(\frac{R^3}{(R^2 + x^2)^{\frac{3}{2}}} - \frac{r^3}{(r^2 + x^2)^{\frac{3}{2}}}\right)\right\},$$

$$H_4 = -\frac{1}{24}\left\{\frac{R^3}{X^3(X^2 + R^2)^{\frac{5}{2}}}(20X^4 + 7X^2R^2 + 2R^4) - \frac{r^3}{X^3(X^2 + r^2)^{\frac{5}{2}}}(20X^4 + 7X^2r^2 + 2r^4) - \frac{R^3}{x^3(x^2 + R^2)^{\frac{5}{2}}}(20x^4 + 7x^2R^2 + 2R^4) + \frac{r^3}{x^3(x^2 + r^2)^{\frac{5}{2}}}(20x^4 + 7x^2r^2 + 2r^4)\right\}.$$

The needle consisted of two parallel lamina of steel of length, l, and a distance, W, from each other. As the correction for length is small, we may assume that the magnetism of each lamina is concentrated in two points at a distance $n\,l$ from each other, where n is a quantity to be determined.

$$\text{Hence}\quad G = \frac{2\pi N}{(R-r)(X-x)}\left\{H_0 + H_2\frac{l^2n^2}{4}Q_2(\theta') + H_4\frac{l^4n^4}{16}Q_4(\theta') + \&c.\right\}$$

where $\cos.\theta' = \dfrac{W}{\sqrt{(\frac{1}{2}nl)^2 + W^2}}$, seeing that the needle hangs parallel to the coils. In short thick magnets, the polar distance is about $\frac{3}{4}l$ and the value of n will be about $\frac{3}{4}$. For all other magnets it will be between this and unity. In the present case $n = \frac{3}{4}$ nearly.

As all the terms after the first are very minute, this approximation is sufficient, and will at least give us an idea of the amount of this source of error.

Induction Coils.

The induction coils were in the shape of two parallel coils of nearly equal size and of nearly square section.

Let A and a be the mean radii of the coils; let b be the mean distance apart of the coils; let $c = \dfrac{2\sqrt{Aa}}{\sqrt{(A+a)^2 + b^2}}$. Supposing the coils concentrated at their centre of section, we know that $M_0 = 4\pi\sqrt{Aa}\left\{\left(\frac{2}{c} - c\right)F(c) - \frac{2}{c}E(c)\right\}$ where $F(c)$ and $E(c)$ are elliptic integrals. If ζ and η are the depth and width of each coil, the total value of M will be, when $A = a$, nearly,

$$M = M_0 + \frac{1}{12}\left\{\frac{d^2M_0}{dA^2}\eta^2 + \frac{d^2M_0}{db^2}\zeta^2\right\} + \&c.$$

and we find

$$\frac{d^2M_0}{dA^2} = -\frac{\pi}{A}\left\{\frac{E(c)}{2A(1-c^2)}\left(2Ac + \frac{4b^2c^3}{8A(1-c^2)}(1 - 3c^2 + 2c^4)\right) - F(c)\left(c + \frac{b^2c^3}{4A^2}\right)\right\}$$

$$\frac{d^2M_0}{db^2} = \frac{\pi c}{A(1-c^2)}\left\{F(c)\left(2(1-c^2) - \frac{b^2c^2}{4A^2}(2-c^2)\right) - E(c)\left(2 - c^2 - b^2c^2\frac{1 - c^2 + c^4}{2A^2(1-c^2)}\right).\right\}$$

[TO BE CONTINUED.]

ON THE PHYSICAL ACTION OF THE MICROPHONE.

By J. Laister, M.S.T.E.

In a paper bearing the above title Professor Hughes has laid before the Physical Society what appear to be his matured views upon the action of his carbon microphone. If they had been published earlier, perhaps they would have escaped criticism, for it must be admitted that no one can be so competent to judge the character of the material employed as the inventor himself, who has carefully watched its behaviour for many months under a multitude of varying conditions. But exception has been taken to his explanation, so far as it was at first known, from two different quarters—one referring the whole proceeding to "fresh contact," the other to "heat;" and, as the writer of the present article was—through the accidental appending of his name to his former paper—made responsible for the second of these solutions, he feels called upon to furnish reasons for it. As a mere personal or speculative question, however, it would not be worth discussing; but the significance and future application of this new discovery greatly depends upon our knowing exactly what it is that has been discovered, and the question is, therefore, essentially practical. We know what the microphone does for us, but what it may be capable of doing will not be determined so long as there is any uncertainty about the true source of its power. In a previous article it was urged that too little attention had been directed to the heat generated at the points of contact. As to the presence of the heat there can be no question: we think we are right in formulating the following, among other statements, in relation to this part of the subject:—that the point of greatest resistance is the point of greatest heat; that the rise of temperature depends on the specific heat of the conductor; that the specific resistance increases as the temperature increases; and that the resistance diminishes when the rise of temperature is caused by the current. We know that some if not all of these laws must be operative at the microphonic points of contact; yet, with the exception of what may, perhaps, be inferentially gathered from the fact that Professor Hughes discards oxidisable metals, hardly anything has been said as to the possible share temperature may have in the work to be done. We propose in this article to reproduce Professor Hughes's own theory in a popular shape, and then to compare its merits side by side with the only other theory pretending to be scientific that has yet been hazarded.

Professor Hughes is reported to have said that he "believed from numerous experiments that the whole block (of carbon) increased and diminished in size at all points, in the centre as well as the surface exactly in accordance with the form of the sonorous wave;" and we single this passage out as embodying the substance of his main contention because although only expressed as his belief, the whole case hangs upon this conjecture being true. Indeed, we may go further, and say that, unless the several parts, wood, carbon, and pencil, all alike expand and contract sympathetically, but in different degrees, with the sonorous waves, the theory will not hold good, for we cannot restrict the action of the waves to one particular object or locality. The first question that occurs to us is whether it is a fact that solid bodies swell out and contract, in the sense here affirmed of them, under sonorous impact? It is one for acoustical experts to answer; but that it is a novel interpretation of the known laws of acoustical science would seem to be admitted, otherwise Professor Hughes would speak of it as well known, not merely as his belief in it. It will also be asked whether carbon, charcoal,

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gold, and platinum are peculiarly good resonant bodies in the usual sense of the term. Exception may also be taken to the constant reference to the "upheaval" of the block, which seems to imply that the sonorous impulses originate from below it, or, at all events, from the *fixed block*, which clearly cannot be assumed in all cases, if, indeed, exclusively in any. In this relation I will venture to describe one or two test experiments which I have made with a view to determining the purely acoustical qualities of the instrument. I detached the carbon tablet, about a centimetre square, and two millemetres thick, and placed it on the top of the graphite pencil, which I held upright in my fingers. The tablet was steadied in its position by the (very fine) connecting wire, but in other respects was quite free, and at times it was nearly falling off. I kept up a conversation with this arrangement, using one Leclanché cell, the only noticeable defect being in the sibilations. The best sounds were given off when the words were spoken downwards upon the *loose block*. At another time I clamped the tablet in a vice and put the pencil underneath, lightly resting the lower end upon a heap of cotton wool with which the space between the two limbs of the vice was partially stuffed. The articulation was imperfect when speaking down upon the fixed block; there was a great improvement when the pencil was spoken at; but it became loud, clear, and perfect in every way when the cotton wool was spoken into.

The inference I drew from these and similar experiments was that the *material*, upon which so much stress is laid, of the microphone itself did not act sonorously, but only mechanically. Why it acts telephonically I will endeavour to explain further on. Again, on balancing a steel rod of considerable length, one end of which touched an iron plate and the other rested upon the edge of a cigar box, both metals being part of a voltaic circuit, the tick of a watch placed upon the box was reproduced with almost microphonic distinctness. I shall probably be told that the rod communicated the sonorous vibrations to the plate just as it would to the ear. There is no denying the vibrations, but what one does object to, however, is that properties are ascribed to the plate or the *material* of the microphone which are not proved to be theirs. I submit that the microphone is not an ear, but a machine, which, for reasons purely electrical, responds to vibrations. If the microphone were responsive to mere sounds like the ear, it would reproduce the ticking of a watch without the aid of a sounding board, but I suppose most people have observed that it does not.

Returning again to Prof. Hughes's own account of the action, he says that the spreading out of the swollen molecules under pressure of the uppermost block results in "innumerable fresh points of contacts" being made. Here we think that he concedes too much to those critics who maintain that "fresh contact points" alone suffice to account for what takes place. There is really nothing to choose between an explanation which assumes fresh contacts by superficial enlargement and one which attributes them to mechanical pressure. Indeed, if Prof. Graham Bell is right in all that he has taught us about undulatory currents and the essential conditions for producing them, it is difficult to conceive how those conditions can be fulfilled by any mere increase or decrease in the number of contact points. We think that Prof. Bell would insist that they must be in a condition to yield and expand in conformity with the vibrations—that, in fact, they must be elastic. Now, it is this, we venture to think, essential characteristic which has all along been overlooked. There is intense heat at the points of contact, and we think it possible that this fact will furnish us with the explanation we need.

To clear the ground a little, we may at once dismiss the microphone considered as a mere sound-finder out of the region of controversy. Heat, no doubt, plays some part in the operation—probably an important part so far as the microphone, lightly adjusted, *correctly* reproduces feeble sounds. But, as a matter of fact, it does not truthfully reproduce them, except under circumstances to which I shall presently revert—and almost any loose explanation, as loose and uncertain as the adjustment itself, will serve. Doing duty as a speaking instrument, it must be treated tenderly; the sounds must reach it enfeebled by distance; that is to say, the disturbing force must be very slight indeed. The fact that when so adjusted, and so treated, it will with tolerable accuracy reproduce articulate speech is strongly corroborative of the explanation we shall suggest of its action when firmly adjusted as a telephonic transmitter. In the ordinary pattern of instrument used for this purpose the points of contact, notwithstanding the firm pressure, are very few in number. A common magnifying glass will remove all doubt on this score; and, whether the discontinuous surfaces are many or few, finally the points which are actually operative can almost be counted. If we admit, and I think we must admit, that these points of extreme resistance, and perhaps some others nearly but not quite in contact, are at a high temperature, we have all the conditions necessary for producing undulatory currents. Heat expands the particles; but it probably does more than this. As it loosens the cohesive force of the molecules, it is not too much to assume that the points are rendered ductile, their ductility depending upon the material employed, the strength of the battery, and the resistance of other portions of the circuit. We will not presume to attempt an exhaustive account of what may now take place; that is the province of scientific investigation which this article invites, but does not itself make pretension to. Our ordinary experience will serve us, however, for present purposes. In this condition of ductility the points will yield to pressure, expanding when the pressure is relaxed, and this, too, whether occasioned by direct sonorous impulse or by mechanical vibrations at second-hand. Compression will reduce the heat by improving the conductivity; rebound follows, and this rebound will not result in a sudden breaking of "fresh contacts," but in a gradual fall of the current consequent upon the rise of resistance. It is worth remarking here that relaxation gives off a sound just as surely as does compression.

On this hypothesis there is no need for *fresh* contact points, or for the doubtful assumption that sonorous waves swell the whole material. The essential conditions, apart from electrical considerations, are mainly mechanical. The blocks must vibrate independently and differently; it does not matter which of them is fixed so long as one is comparatively free; as Professor Hughes well puts it, if they moved simultaneously in the same direction the surfaces would for all practical purposes be continuous.

It will require more delicate appliances and more leisure than the writer has at his disposal to settle this question one way or the other; but the following facts have some significanc.

First, there is the totally different behaviour of the instrument in its twofold characters of speaking transmitter and sound-finder. Adjusted for the former purpose, the arrangement greatly favours the operations Professor Hughes has depicted, namely, the enlargement of the block under feeble, sonorous vibrations, the spreading out under pressure from overhead, and the making of fresh contact points. Yet, in reality, it is necessary to concentrate the whole force of the sonorous waves close upon the instrument to get the effect we desire. On the other hand, when the pencil is merely allowed to touch—it can scarcely be said to rest upon—the block, articulate speech is reproduced even when the sounds originate several feet away. If the pencil were steadied, but not weighted, the articulation would, I have reason to think, be quite as sure and clear as with the firm adjustments. To explain this by what we will call, for brevity's sake, the acoustical theory involves, therefore, the extraordinary proposition that the microphone gives the best results—if sensibility is a test of excellence—when all the conditions are most unfavourable. But in the electrical theory we seem to have a simple and sufficient explanation of these apparent contradictions. At the loose contacts the temperature is the highest possible, and the pliability of the point or points is at its maximum. The force capable of actuating the instrument may, therefore, be very feeble indeed. With the weighted contact points of the transmitter the converse is the fact, and this is what we might expect if the electrical explanation were true.

Secondly, there is the character of the material employed. Mr. Lascelles Scott says that he gets the best results using platinum, and Professor Hughes obtains the very best with gold. Now, the specific heat of these two metals is exactly alike, and their conductivity of heat is nearly so. Carbon, it is true, is widely different, except in respect to its freedom from oxidation; but that it is serviceable for microphonic purposes may be partly due to its structure and its rough surface.

Lastly, the insertion of additional resistance into the circuit alters the sensibility of the instrument very materially; and this, I submit, should not be the case if the acoustical explanation were true. By adding a second microphone, I have found that the ticking of a watch on the sounding-board of either is rendered much less audible, and, on compelling the current to pass through a narrow vessel of water the instrument becomes, for microphonic purposes, almost dead, although a galvanometer inserted will show that a current is still flowing, far stronger than what is actually needed to obtain good results when no superior resistance is included in the circuit.

I have not space to go into the matter more fully, but enough has perhaps been said to suggest further investigation by more competent hands than mine. If the faithful conversion of sound waves into electrical waves can only be accounted for by assuming the ductility of points of high resistance, the fact may have a wide significance for electricians generally; but, whether this be so or not, the genius to which we owe this wonderful appliance is happily in Prof. Hughes associated with a disposition that will be the last to take exception to criticism which has had no other aim than that of extending the practical usefulness of his discovery.

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SCIENTIFIC PROGRESS.

That we live in an epoch of wonderful discoveries is a truism the truth of which is far too little appreciated. We have the thought as seldom in our minds as the phrase often on our lips. Human nature is ever prone to keep its eyes fixed on the low, level features of life, and each generation seems to be living in the most uninteresting and uneventful of ages. We are like the boor who at sunrise trudges over a lofty mountain top, and sees nothing but fields and hedges, cattle and cottages, while to the gazer from a further range all these commonplace details are lost in a glow of light and colour. For future ages it is reserved to know the worth of ours in its full glory and proportions. Only now and then, as we compare yesterday with to-day, some flash of insight reveals for a moment the true significance of what is going on around us in this dull nineteenth-century light; then, perhaps, we start and ask ourselves if it is a dream, or if to-morrow is indeed to owe more to our generation than to the work of a hundred half-forgotten centuries.

These are boastful words, but are we not justified in their use? Every age is, in a sense, an age of transition; yet, in scientific development, as in other forms of progress, there are pregnant epochs, spasms of conception and production, marked transcendings of the ordinary rule of growth. We have known the beginning of such an epoch, the end of which is not yet apparent. If discovery does not slacken its pace, but proceeds at a rate accelerated by multiplying means of information and comparison, the infant born to-day may live to look on the surroundings of our life as a strange form of barbarism. Scarcely any discovery can be imagined too astounding to be incredible, after all that has happened within one generation. There are men still living who can remember when the very name of Evolution, the governing idea of scientific thought, was scarcely known, when our now familiar laws of matter and force were mysteries to the profoundest philosopher, and when dreams and guesses were the only explanation of phenomena which are daily weighed, measured, and dissected by the veriest apprentice of science.

In electricity more than any other path of science is this progress evident. It is but half a century ago that to circle the earth in forty minutes became more than a poet's imagination. Since then, improvements in the electric telegraph have come with something of its own speed, one following another almost before the public mind could realise the importance of what had been already superseded. It was only yesterday that that we were laughing at the very notion of the telephone. To-day we are opening our eyes at the microphone, uncertain as yet what to think of its extraordinary phenomena. And, from sources that cannot be named here, comes information of experiments the results of which already give reason to expect that we are on the eve of a still more stupendous electrical discovery.

For us who handle these marvels day by day, it is surely good to pause and reflect upon them, lest in our familiarity we forget how marvellous they are. The undevout astronomer, it has been said, is mad; and so must the head of the frivolous electrician be at fault as well as his heart. It is a grave mistake to think that hardness and narrowness of mind are necessarily produced by scientific studies. There are men, both learned and ignorant, to whom a "primrose by the river's brim" is a mere worthless yellow flower, or a mere member of such and such a class and order, and nothing more; but to one who has wisely studied nature, the humblest weed is a manifestation, no less wonderful than the thunderstorm or the rainbow, of the mighty forces pervading time and space. Science, indeed, opens out new and infinite fields for reverence to the mind of man, and, if he behold not, the fault is in his own blindness. Too much has knowledge been distrusted in the past. A monopoly of the nobler intellectual qualities has been too commonly claimed by the complacent bigot who fondly takes his microscopic ideas for the centre of all things, who announces that in his duck-pond of individual or sectarian opinion we must look for the boundless ocean of truth, and who, perhaps, professes to calculate to an hour and a day when this petty existence is to fall in ruins. But how much greater must be his awe and earnestness who has learned that our deepest thought and our loftiest imaginations only serve to reveal to us our own littleness, that the engrossing joys and sorrows of each one of us are but as a grain of sand amidst the immeasurable energy through which we have our being; nay, that all our world's history, its thousand years of wrongs and glories, of loves and hates, of doing and suffering, its myriad millions of births and deaths, is nought but a pulse-beat in the eternal life of the Universe.

Into what are usually called religious matters, we, of course, do not enter, yet, surely, we may urge that our work is one to be done in a devout spirit. All the best work of the world has been done in such a spirit, and no such worker has lost his reward, however he may have seemed to miss it. It is useless to argue this point with the cynics who point to the inventive genius dying in obscure poverty, while the prosperity and audacity of the quack are recorded in a thousand advertisements. No words can hint to a mean nature the satisfaction of having done something to benefit one's fellow men, but to a great soul there is no richer prize. And what, if we work unknown, or if, as is the case with all but one in a thousand, our work be not to lead, but to follow and serve the leaders? Little or great, famous or unknown,

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should not matter to the true man; it is the how and not the how much that concerns him most:—

The noblest service comes from nameless hands,
And the best servant does his work unseen.
Who found the seeds of fire and made them shoot,
Fed by his breath, in buds and flowers of flame?
Who forged in roaring flames the ponderous stone
And shaped the moulded metal to his need?
Who gave the dragging car its rolling wheel,
And tamed the steed that whirls its circlings round?
All these have left their work and not their names,
Why should I murmur at a fate like theirs?

Rightly looking to the end, we ought to forget our own glory and profit, and considering what a cause and what instruments are ours, we should patiently and hopefully devote ourselves that through our labour life should be left to our children better and wiser than we found it. Thus is it in the hands of every electrician to help or hinder scientific progress.

EDISON'S MICRO-TASIMETER.

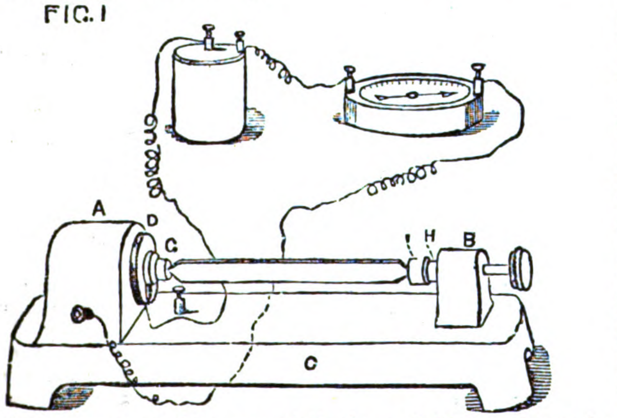
The latest of Edison's inventions, says the *Scientific American*, and perhaps the most interesting to physicists, is his micro-tasimeter, or measurer of infinitessimal pressure.

The thermopile, hitherto foremost among delicate indicators of changes of temperature, must now be consigned to the rear ranks, and the radiometer, which exhibits the motive power of the most subtile of forces, must retire in favour of an instrument that can weigh that force.

The micro-tasimeter is the outcome of Professor Edison's experiments with his carbon telephone. Having experimented with diaphragms of various thicknesses, he ascertained that the best results were secured by using the thicker diaphragms. At this stage he experienced a new difficulty. So sensitive was the carbon button to changes of condition, that the expansion of the rubber telephone handle rendered the instrument inarticulate, and finally inoperative. Iron handles were substituted with a similar result, but with the additional feature of musical and creaky tones distinctly audible in the receiving instrument. These sounds Professor Edison attributed to the movement of the molecules of iron among themselves during expansion. He calls them "molecular music." To avoid these disturbances in the telephone, the handle was dispensed with; but it had done a great service in revealing the extreme sensitiveness of the carbon button, and this discovery opened the way for the invention of the new and wonderful instrument.

The micro-tasimeter is represented in perspective in Fig. 1, in section in Fig. 2, and the plan upon which it is arranged in the electric circuit is shown in Fig. 3.

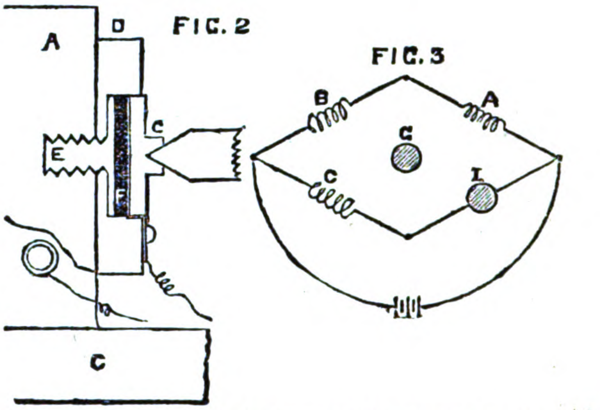
FIG. 1



The instrument consists essentially in a rigid iron frame for holding the carbon button, which is placed between two platinum surfaces, one of which is fixed and the other moveable, and in a device for holding the object to be tested, so that the pressure resulting from the expansion of the object acts upon the carbon button.

Two stout posts, A, B, project from the rigid base piece, C. A vulcanite disc, D, is secured to the post, A, by the platinum-headed screw, E, the head of which rests in the bottom of a shallow circular cavity in the centre of the disc. In this cavity, and in contact with the head of the screw, E, the carbon button, F, is placed. Upon the outer face of the button there is a disc of platinum foil, which is in electrical communication with the battery. A metallic cup, G, is placed in contact with the platinum disc to receive one end of the strip of whatever material is employed to operate the instrument.

The post, B, is about four inches from the post, A, and contains a screw-acted follower, H, that carries a cup, I, between which and the cup, G, is placed a strip of any substance whose expansibility it is desired to exhibit. The post, A, is in electrical communication with a galvanometer, and the galvanometer is connected with the battery. The strip of the substance to be tested is put under a small initial pressure, which deflects the galvanometer needle a few degrees from the neutral point. When the needle comes to rest, its position is noted. The slightest subsequent expansion or contraction of the strip will be indicated by the movement of the galvanometer needle. A thin strip of hard rubber placed in the instrument exhibits extreme sensitiveness, being expanded by heat from the hand, so as to move through several degrees the needle of a very ordinary galvanometer, which is not affected in the slightest degree by a thermopile facing and near a red hot iron. The hand, in this experiment, is held a few inches from the rubber strip. A strip of mica is sensibly affected by the heat of the hand, and a strip of gelatine, placed in the instrument, is instantly expanded by moisture from a dampened piece of paper held two or three inches away.



For these experiments the instrument is arranged as in Fig. 1, but for more delicate operations it is connected with a Thomson's reflecting galvanometer, and the current is regulated by a Wheatstone's bridge and a rheostat, so that the resistance on both sides of the galvanometer is equal, and the light-pencil from the reflector falls on 0° of the scale. The principle of this arrangement is illustrated by the diagram, Fig. 3. Here the galvanometer is at G,* and the instrument, which is at I, is adjusted, say, for example, to ten ohms resistance. At A, B, and C the resistance is the same. An increase or diminution of the pressure on the carbon button by an infinitesimal expansion or contraction of the substance under test is indicated on the scale of the galvanometer.

The carbon button may be compared to a valve, for, when it is compressed in the slightest degree, its electrical conductivity is increased, and when it is allowed to expand it partly loses its conducting power.

The heat from the hand, held 6 or 8 inches from a strip of vulcanite placed in the instrument—when arranged as last described—is sufficient to deflect the galvanometer mirror so as to throw the light-beam completely off the scale. A cold body placed near the vulcanite strip will carry the light-beam in the opposite direction.

Pressure that is inappreciable and undiscoverable by other means is distinctly indicated by this instrument.

Professor Edison proposes to make application of the principle of this instrument to numberless purposes, among which are delicate thermometers, barometers, and hygrometers. The *New York Herald* of June 22 gives the following interesting report of a visit to see this apparatus:—"Hitherto the most delicate instrument known to science for determining the heat in the different parts of the solar spectrum has been the thermopile. The great improvement of the tasimeter over the thermopile is illustrated in a simple manner by Professor Edison. A few inches from the former he placed a hot iron. It deflected the needle of an ordinary galvanometer one degree; then he held his little finger four inches from the tasimeter with the same galvanometer, and it swung the needle around six degrees. In explaining the workings of his new invention to a *Herald* reporter in his laboratory at Menlo Park yesterday, the inventor said:—'We now study chemistry by means of the sun. We have found, by the aid of the spectroscope, that there are metals in the sun which are un-

* The galvanometer should be connected to the angles vertically above and below it

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known on earth, as well as metals here, the existence of which in the sun have thus far not been discovered.' The Professor then made a number of curious experiments. 'See here,' said he, taking a thin strip of vulcanised rubber, and placing it between two small upright iron posts in his tasimeter, 'this is highly sensitive to heat—a little causes it to expand. At this end I place my carbon. I found out that silk coated with conducting lamp-black, pressed in the form of a button, was wonderfully sensitive to the passage of the electric current. Put upon it the pressure of one half-millionth of an inch, and it will allow the passage of a current strong enough to deflect Sir William Thomson's galvanometer one degree. Of course greater pressure deflects the needle more.' Professor Edison then took an ordinary galvanometer and put it in electric circuit with his tasimeter, and held his hand four inches away from the vulcanite strip. Instantly the needle of the galvanometer moved five degrees. Next he lighted a gas jet five feet away, and the needle moved four degrees. Then he held a match a distance of six inches, and the heat indicated eleven degrees in the galvanometer. Breathing slightly on the rubber expanded it sufficiently to mark thirty degrees. These results the professor produced without the improved galvanometer, which he explained was infinitely more sensitive. Professor Edison next introduced between the posts a slip of gelatine, in order to measure moisture. Moistening a piece of paper slightly with his tongue, he held it three inches away. The deflection was eight degrees. A breath on the gelatine moved the pointer thirty-five degrees. A drop of water on the end of his finger, held five inches away, indicated a moisture of eleven degrees. A lighted cigar, at a distance of nearly a foot, dried the atmosphere sufficiently to cause a deflection of seven degrees. Water in a bottle held near by made the needle vibrate. *The Eclipse of the Sun.*—The professor next explained the method proposed to be adopted in the astronomical experiments to be made with his tasimeter. Instead of vulcanized rubber, platina will be used, the latter having been found to gain and lose heat much more readily than the former. The tasimeter, unlike the one experimented on as above, is to be smaller and of different material, brass being used throughout. It will be enclosed in a recepticle of tin, which in turn is placed in a second recepticle of the same metal. Between the two will be kept boiling water for the purpose of preserving evenness of temperature, as boiling water attains no higher temperature than 212° F. The spectroscope will then be made to concentrate the heat into a small opening in the tasimeter, where, falling on the platina, it will cause expansion and corresponding pressure of the small carbon button allowing the passage of the electric current in a degree commensurate with the pressure. Attached to and forming part of the tasimeter is an appliance for measuring the degree of expansion or contraction of different metals under similar temperatures. Professor Edison found the heat of his hand expanded the platina one five-thousandth part of an inch. The great inventor has already taken steps to use his new discovery for the protection of vessels at sea. He stated to the writer his method as follows:—'I arrange the carbon button as a highly sensitive barometer, and, enclosing it in a case, connect it with the keel of a ship. I then run a wire to the captain's room into an ordinary galvanometer. Any change of temperature, as you see, is at once indicated. Coldness of the water will contract and warmth expand, and the corresponding deflections be placed at once before the eye of the captain. The approach of an iceberg will, therefore, be known long before there is danger of collision. It may also be used to indicate any abnormal heat in any part of the ship's hold, thus giving timely notice of the breaking out of fire.' In experimenting on his tasimeter Professor Edison made a highly valuable discovery in telegraphy. Ever since the first line was successfully worked by Professor Morse the great and apparently insurmountable obstacle to constant and uninterrupted communication was the effect produced on the electric current by changes in the atmosphere. Rain always made the lines work with difficulty, and, frequently in heavy storms the escape of the subtle fluid into the moist air made the wires practically useless. The Professor's discovery is what he calls an "electric governor," acting on the telegraph line as a steam governor does on an engine. It obviates the necessity of "adjusting" the magnet armatures along the line. One placed in the circuit regulates the entire line, preserving an evenness of current throughout. The loss of fifty per cent of the battery power is felt no more than a corresponding gain. Diminution in the strength of the battery from any cause, atmospheric or otherwise, is prevented by the "governor" from having any perceptible effect on the instrument on any part of the line. The Professor desired it to be understood that the discovery was based on a suggestion by a practical telegrapher. Professor Edison has also found by his experiments with the tasimeter that it will weigh infinitessimal articles as well as their moisture. For instance, he took a fibre of paper, and by placing it in his new apparatus found it to be quite heavy. Then he experimented on a gnat, connecting the instrument at the same time with his most sensitive telephone. The result was the deflection of the galvanometer to indicate the weight of the diminutive insect, while the telephone echoed the sound made by the insect's feet on the disc. By arranging it with an anemometer arm and cup and causing the lever to press on the tasimeter, it recorded the pressure of a faint gust of wind. Notwithstanding the heavy drains on his intellect by the numerous wonders in process of construction in his laboratory the professor continues daily at work perfecting his megaphone. Yesterday he placed the field megaphone in front of his laboratory, and gave the rubber tubes to the writer so that he might personally test its strange power. Then he hurried across lots nearly a mile, and standing on the brow of a hill whispered, 'Do you hear this?' The words came distinctly, notwithstanding quite a breeze was blowing at the time. When he spoke in his ordinary tone the words reached their destination as distinctly as if the distance intervening were a foot instead of a mile. Again he whispered, giving the legend of Mary and her little lamb. Every word was heard by the writer with perfect distinctness."

ON THE STUDY OF ELECTRICITY AS A PROFESSIONAL PURSUIT.

BY THOMAS T. P. BRUCE WARREN.

V.

In concluding my remarks on the management, &c., of batteries, I would point out the importance of making one's self acquainted with the principal forms of batteries in use, such as the Leclanché battery, the chromate battery, and others which, having distinct claims to originality, are suited for different purposes.

No one would think of employing a form of cell designed for constancy in testing high resistances for such purposes as working on small resistances, electrotyping, &c. The consumption of material depending upon the amount of work required to be done must be steadily borne in mind.

For scientific investigations constant batteries are indispensable, and the student who has made up his mind to devote a little attention to this subject is strongly advised to *make himself acquainted* with the cell constructed by Mr. Latimer Clark, which is described as follows in the *Journal of the Telegraph Society*, Vol. II, page 25 :—

"This battery is composed of pure mercury as the negative element, the mercury being covered by a paste made by boiling mercurous sulphate in a thoroughly saturated solution of zinc sulphate; the positive element is a small cylinder of pure zinc resting on the paste. The best method of preparing it is to dissolve pure zinc sulphate to saturation in boiling distilled water. When cool the solution is poured off from the crystals and mixed to a thick paste with pure mercurous sulphate, which is again boiled to drive off any air; this paste is then poured on the surface of the mercury previously heated in a glass cell. A piece of pure zinc is then suspended on the paste, and the vessel may be advantageously sealed up with paraffin wax. Contact is made with the mercury by a platinum wire passing down a glass cemented to the side of the cell, and dipping below the surface of the mercury, or by a small external glass tube blown on to the cell and opening into it close to the bottom. A cell an inch in height is sufficient for all purposes, as it is not required to produce any sensible current. The mercurous sulphate ($Hg_2 SO_4$) can be obtained commercially, but should be very carefully washed in distilled water to free it from acid, with which it is frequently contaminated. Care should also be taken to obtain it free from mercuric sulphate (persulphate), the presence of which is known by the salt turning yellowish on the addition of water: the presence of acid or persulphate would considerably affect the electro-motive force. Standard elements thus prepared are perfectly uniform in their electro-motive force, and remain so certainly for eighteen months, and probably for an indefinite time, provided the battery is not allowed to work."

The advice here given applies to all forms of constant batteries. I may add to this that I found a cell remain perfectly constant for nearly four years, and until within a short time of its failing altogether. Its action ceased from the contents becoming dried up.

A thin beaker of two ounces capacity makes a very convenient cell: a thick glass will not stand the heat, as it is necessary to keep it hot, and to put the battery together whilst the materials are warm. Free acids or acid salts are bad to be used in any form of constant cell. Some time ago I had several of these cells put up, and for a day or two afterwards they appeared con-

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stant and equal in electro-motive force to a cell obtained from Mr. Latimer Clark. They then fell off rapidly. It was found that the sulphate of mercury was impure, the mercury itself was probably impure, and the zinc sulphate as well. Pure materials were then used; and the cells put up behaved satisfactorily, failure arising from their becoming dry. On foreign stations, it is most important that the materials for putting such a battery together be included among the electrician's stores.

With a fair amount of care and well-prepared materials, a reliable standard of electro-motive force could be readily made. The best plan would be to make up a cell, say at intervals of eight or ten months, and to test the new one against the old one. In this way every station may always have a unit for comparison agreeing with one set up anywhere else.

I am disposed to think that this cell has not met with that appreciation among electricians generally which it deserves.

A few Clarks' cells and a quadrant electrometer would form an important adjunct for working on small faults, and, if the electrician had time for a few experiments on earth currents, he would have an easy and reliable means at his disposal for communicating his results in a system which would admit of direct comparison. These cells, however, run down very rapidly even if bridged over with a resistance of 100,000 units, and I would therefore advise that the comparison of different currents from different sources with this battery should be made on an electrometer in preference to any other method.

The measurements of the internal resistance of batteries ought also to be a subject of which the electrician is fully acquainted. The method given by Sir William Thomson for the quadrant electrometer is certainly the most convenient, whilst its disadvantages are not more objectionable than any of the galvanometric methods proposed. I have invariably used the electrometer method, which has everything in its favour. In all cases it is well to bear in mind that the electro-motive force is liable to alteration when the battery terminals are joined together; therefore these tests should be made as rapidly as possible.

The measurements of the internal resistance of batteries may be made with the sine and tangent galvanometers. Although these methods are not much used by the electrician for telegraph purposes, it is easy to see that there may be circumstances which might render the use of more delicate instruments inappropriate.

Amongst the galvanometric methods may be mentioned that of Du Moncel. The reader will at once perceive that it forms the basis of all subsequent methods whether with galvanometers or electrometers :—

"Je commence à déterminer, au moyen d'un boussole des sinus, l'intensité I. de la source électrique dont je veux mesurer la résistance, en introduisant dans le circuit une résistance, *r*, de 12 ou 15 kilomètres de fil télégraphique de 4 millimètres. Je dérive ensuite le courant en réunissant les deux pôles de la pile par un fil de résistance connue *b* que je regarde comme résistance type, et qui doit être d'autant plus résistant que la pile est plus résistante (2 ou 3 kilomètres environ). Enfin, je déroule de dessus le rhéostat une quantité de fil suffisante pour que l'intensité du courant à travers cet instrument reste la même, ou en d'autres termes pour que la boussole des sinus donne la même indication que, quand le circuit étant simple, la résistance du rhéostat était *r*. Calculant alors la résistance *a* du rhéostat après cette opération, je me trouve en possession de tous les éléments nécessaires à la détermination de la résistance R du couple.

"En effet, d'après les lois d'Ohm, l'intensité du courant dans le circuit simple de résistance *r* est representée par : $I = \frac{E}{R + r}$, et dans le même circuit, de résistance *a* après la derivation par : $I = \frac{E\,b}{R\,(a + b) + a\,b}$. Comme les deux intensitiés sont égales, on peut passer $\frac{E}{R + r} = \frac{E\,b}{R\,(a + b) + a\,b}$, d'ou $R = \frac{b\,(r - a)}{a}$.

On va voir par l'exemple suivant les avantages de cette méthode.

"En expérimentant d'après la méthode ordinaire une pile de Daniell à vases poreux, très perméables, j'ai trouvé, pour les circuits *r* et *r* ayant le résistance de 11,829 et 14,749 mètres, de fil télégraphique de 4 millimètres, des intensités représentées à ma Boussole des sinus par 29° 50′ et 23° 45′. Avec ces données, la valeur de R était 586 mètres, la force electromotrice 6,175, et la valeur de I en sinus 0·40275. En établissant une dérivation entre les deux pôles de la pile par un fil 417 mètres de résistance, il m'a fallu réduire la résistance *r* de 14·749 mètres à 7·505 mètres pour obtenir la même intensité 0·40275.

"Si les valeurs de E et R déterminées précédemment par la méthode ordinaire étaient exactes, il faudrait qu'appliquées à la formulo $\frac{E\,b}{R\,(a + b) + a\,b}$, elles pussent fournir la valeur 0·40275. Or ou trouve une valeur notablement moindre, c'est a dire 0·33865.

"Partons maintenant de la nouvelle formule $R = \frac{b\,(r - a)}{a}$, nous trouvons $R = \frac{417\,(14749 - 7505)}{7505} = 402$.

"Or cette valeur, en nous fournissant cette fois (au moyen de la formula des courants dérivés) l'intensité 0·40780, quantité bien insuré de celle reconnue par l'expérience, nous donne avec la formule du circuit simple 0·40756 pour la même valeur de I′.

"On voit donc que les valeurs de R, déterminées par la méthode précédente, sont forcément plus exactes que les autres, puisqu' elles peuvent satisfaire à toutes les expériences ce que n'a pas lieu avec les valeurs fournies par la méthode ordinaire."*

In the reflecting galvanometer, where I. may be taken as being proportional to the deflections obtained, the angular values will of course disappear.

Thus, if S represents the resistance used to bridge over the battery terminals, and the resistance R and *r* respectively, give the same deflection, then res. of battery $= S \times \frac{R - r}{r + G}$.

This is quoted by Mr. Latimer Clerk as Sir William Thomson's method.†

The advantage of thus performing the test is its rapidity, diminished chance of error in reading the scale indications, and simplicity of the calculation.

I would, nevertheless, advise no one who has the opportunity of experimenting with a sine or tangent galvometer, to omit the opportunity of such an advantage.

To familiarise one's self with every method of testing should form one of the principal aims of the accomplished electrician. Such experience, though it may not lead to an immediate application, may help towards the more ready comprehension of a subsequent developement.

In testing batteries for their "working" capabilities, the best plan is to join up their terminals with a resistance at least equal to the lowest resistance they may be required to work through. When this resistance is very low it is evident that the terminals should be perfectly clean, and no alteration in the battery itself which will increase its resistance ought to happen without being noted.

Polarisation, the deposition of hydrogen on the plates, must not be omitted when carefully comparing batteries for this purpose. The batteries ought to be at perfect rest, without any chance of disturbance.

The voltameter does not appear to have been much used for this purpose, although it possesses great convenience, and I am inclined to think would obviate the uncertainty due to alteration of connections, variation in instruments, and other disturbing causes.

Corrections for barometric pressure and temperature would be necessary where great accuracy was required, but the omission of these would certainly involve no greater error than would be due to galvanometric measurements.

I regret to say that I have never seen a voltameter among the electricians' apparatus for testing or experimenting. If a voltameter be used it is better to measure the hydrogen as the reference for comparison, since it is much less soluble in water, and its bulk being greater than the oxygen the error in reading is reduced.

A convenient form of voltameter for such purpose will be noted in a subsequent paper.

The electrical student has a very fair ground of complaint against the text-books on electricity which have recently been published. The writers generally have shown a great deal of its application to telegraphy, and little beyond this; in fact, if a work were written including all its applications, we should require something approaching the dimensions of an encyclopædia, and, in short, sooner or later, we hope some one will be found willing to undertake this task. One great omission is in not pointing out for the guidance of the student what methods are preferable to others for practical use. The recent discovery of the microphone and the developement of the telephone will necessitate, if introduced into electrical books, an unabridged treatment of the science of acoustics. Thermo-electric currents, which, only a few years ago, were interesting experiments only, have recently assumed an important practical developement.

Magneto-electricity has also lately met with such important application in electro-plating and illuminating that no scanty treatment of this subject should be admissible in our future works on electricity and magnetism. Such portions of chemistry and engineering which an electrician ought to know cannot be reasonably excluded. A knowledge of the machinery and appli-

* 'Annales Télégraphiques,' tome vii., année 1864.

† Electrical Measurement.

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ances used in the construction and mechanical testing of cables during their manufacture, laying, and repairing, cannot be regarded as superfluous, and the same may be said of a few other branches of applied science.

Electricity applied to mining purposes and the firing of torpedoes are almost sealed subjects even in our most recent works.

The measurements of currents by means of Clark's potentiometer method will be dealt with in a future paper.

I shall conclude this paper by giving an instance of the utility of chemistry to the electrician. A few years ago I was asked to coat some copper wire with a deposit of brass, and at that time I was unable to find any information to guide me. I assumed that with suitable battery power, it should be as easy to throw down a definite compound metal as minerals.

I then analysed a piece of sheet brass which was to form the positive conductor in the depositing trough. Finding then that an eight-cell Daniell's battery would cause a deposit of the copper only, when the salts mixed together were the sulphates of copper and zinc, I precipitated the sulphates separately with cyanide of potassium, and dissolved the precipitates in a solution of cyanide of potassium. From this solution I could easily obtain, at a temperature of 80° F., a deposit having almost the same composition which would be represented by an alloy formed of the zinc and copper contained in the solution.

[TO BE CONTINUED.]

CORRESPONDENCE.

TELEGRAPH CIPHERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It is gratifying that my letter, which you did me the favour of inserting on the 22nd ult., has drawn forth the further article by Sir James Anderson in your issue of the 6th inst., as all his remarks are so clear, forcible, and instructive. Yet, somehow, the lessons they teach appear to be exactly the opposite of what he means to convey.

(1.) His criticism of Mr. Whitelaw's carefully-prepared work confirmed our own experience of its value for correct telegraphing.

(2.) His very just claim for the consideration rightly due by merchants to the telegraph companies, in the selection of ciphers least likely to require repetition, leads to wonder that he should put down the very work eminently calculated to promote the end he has in view, and which could be still further improved and modified.

(3.) His mention of the very great difficulty of getting operators to spell, and not to read, seems directly an argument in favour of non-familiar words, instead of the familiar words he pleads for. We find, on the whole, non-familiar words very correctly transmitted.

(4.) He says that philological detectives would be needed if Whitelaw's system were recognised. On the contrary, such is the case at present; but, if works such as Whitelaw's, rightly framed, were recognised, what need for detectives? It is quite the wish of all of us only to use ciphers from ordinary dictionaries or specially recognised works, and this was the motive for bringing Whitelaw's work forward in the way it was done.

(5.) He states that they tolerated Whitelaw's words about a year, though cognisant of their existence, but that when they were brought up in a straightforward way for official recognition they had to put them down. Quite true; we have been taught a lesson, not to treat telegraph officials in an open and straightforward way in these matters again. But we could wish that it were otherwise.

(6.) The statement that the odd unintelligible combinations, which are growing so fast on Eastern lines, are comparatively rare on the American lines, seems to show the effect of the 10-letter limit. It forced us, Eastern merchants, to seek ciphers from foreign sources to an extent that would not otherwise have occurred to us. To tie us down to a 10-letter limit, and then blame us for taking full advantage of it, is both puerile and most unfair.

My argument for a high tariff, combined with the free use of all legitimate ciphers, as best both for the telegraph companies and the merchants, is much strengthened by what Sir James mentions as to the experience of the Anglo-American Company. I have never suggested that the tariff should be lowered, but that it should be adjusted to the companies' experience of the St. Petersburg Rules, either lowered or raised, as such experience determines. There is a vast amount of telegraphing which would not take place at all but for what Sir James calls "packing." With one particular class of business, none of our separate transactions is under 20,000*l*. They range from that amount to 70,000*l*. Cost of telegraphing in these cases is a mere bagatelle, relatively to the amount involved, even if each transaction requires five or six messages costing 25*l*. or 30*l*. But it is a very different matter when it affects varied assortments of goods of small value each, say from 200*l*. to 500*l*. In one class of business we have 1,500 of these assortments. With all the care, forethought, and packing possible, we cannot bring the telegraphing on these under a half to one per cent.; that is to say, while telegraphing on, say 25,000*l*. of our larger transactions may cost us 20*l*., on our small transactions to the same amount it never costs less than 125*l*., and often more than double that. In these days of bare working and competition, such a heavy tax tends to the destruction of business of this sort *by wire*. Therefore, the plea for plenty of ciphers, nicely arranged, like Whitelaw's, is to enable us to bring such business within the pale of telegraphing. Sir James says, "No one telegraphs more than he can help." Not so; every merchant would conduct all his business by wire if he could do so profitably. But, if telegraphic charges take away all his profit, it is clear that he will not work for the benefit of the telegraph companies alone, and must arrange so as to be independent of them.

Sir James, I notice, has selected 19 of the uncouthest of Whitelaw's combinations. These and all the others of the 100,000 are perfectly explainable and intelligible words. Whitelaw did not manufacture; he prefixes and affixes, and could not make them any other than they are in the authorities on which his work rests. But I see it would be useless to attempt any more reference to such authorities. Sir James, in these matters, is "a law unto himself."

In taking leave of this subject, I must just hope that, on the whole, this discussion will enable each side better to understand and appreciate the interests of the other. ANGLO-INDIAN.

8th July, 1878.

P.S. I am sure that none of the large merchants in the Eastern trade would dream of tendering such words as Sir James, quotes "hookeding," "jumpedful." To protect the telegraph companies against spurious words a schedule might be attached to each message form, in which the words in the message and the word they are taken from should be entered thus:—

Jonathan	Hebrew Bible
Nobocoomar	Bengal Directory
Umberleigh	English Gazetteer
Amberby	Whitelaw's Words
Spigolammo	Italian Verb
Chemical	English Dictionary

and so on. Double tariff to be recoverable for spurious words, if detected, within one month from the date of the message. This, I think, would be an effectual protection, and what no one could complain of.

A MORNING WITH THE WEATHER OBSERVERS.

The Signal Service, United States Army, Division of Telegrams and Reports for the Benefit of Commence and Agriculture, is expected, in the language of General Myer ("Old Probabilies"), Chief Signal officer, to perform the following duties:—"To give protection to commerce by warnings on all of the Atlantic and Gulf coasts of the United States, and on those of the lakes; to watch the river changes along their courses in the great river valleys; to note at seasons the temperatures affecting canal commerce; to carry telegraphic lines, by which meteorological reports may be had, over regions considered impracticable for such constructions; to maintain a system of connected stations on the seacoast; to take charge of the recognized system of voluntary meteorological observations on this continent, in addition to the regular system of the service; to secure the co-operation of foreign observers in foreign countries; to endeavour to aid directly all the farming population in the harvesting of their crops; and, finally, to put it in the power of every citizen to know each day, with reasonable accuracy, the approaching weather changes."

How is this done? For it is right to say that these expectations are met, and with continually growing accuracy.

In the first place, there is a thorough course of instruction given to those who are to be observers, both in military signalling and telegraphy, meteorology, and the Signal Service duties at stations of observation and report. This is done at the school of instruction and practice at Fort Whipple, Va. There were at this post, at the last report, seven commissioned officers, of whom four were under instruction, and forty-two enlisted men. There were on station duty, June 30, 1876, the date of the last report, 103 sergeants, 9 corporals, and 94 privates.

There are in the United States in all 171 stations, classed as follow:—Stations making full telegraphic reports, 92; making

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observations and reporting by mail, 15; printing stations at which observations are not made, 3; special river stations, 23; stations on telegraph lines, 38. Reports are also received from seven stations in the West Indies, six of them making full telegraphic reports; and from sixteen British-American stations, all but one reporting by telegraph.

The average cost of maintaining each station of observation during the year, exclusive of the cost of the telegraphic service, and of the pay and maintenance of the men on duty, was $424 03. It may be said here that the sum of the pay and allowances of the men scantily compensates for their continuous labour.

The duties of the enlisted men at each station are defined in the report as follow:—"At stations forwarding telegraphic reports they are required to take, put in cipher, and furnish, to be telegraphed tri-daily on each day, at different fixed times, the results of observations made at those times, and embracing in each case the readings of the barometer, the thermometer, the wind velocity and direction, the rain-gauge, the relative humidity, the character, quantity and movement of upper and lower clouds, and the condition of the weather." These observations are taken at Washington mean time, coming, therefore, earlier at some points, and later at others, making simultaneous observations all over the country. There are also three observations to be taken at the local times, 7 a.m., 2 p.m., and 9 p.m. A special observation is also taken at noon each day, in part at least, to notice any instrumental changes that may require to be reported.

In addition to the reports in the papers, there are also furnished daily to such post-offices as can be reached from convenient centres what are called the Farmers' Bulletins. New York, for example, prints and sends out 703 of these bulletins to as many offices as as can be reached by mail not later than 2 o'clock p.m. of each day.

With the increase of stations, and especially with the growing familiarity of the men of the service with their duties, it was to be expected that there would be an increase in the per-centage of verifications of the "probabilities" or "indications." This has been the case. In 1872 the percentage of verifications was 76·8; in 1873, 77·6; in 1874, 84·4; in 1875, 87·4; and in 1876, 88·3. An average of 90 per cent. of accuracy is believed to be attainable. A series of tables shows that the annual average of disasters to shpping has been lessened by a considerable per-centage for the years during which the display of cautionary signals has been made. While warnings unnecessarily given may delay the movements of vessels, yet a more heavy responsibility would be incurred if the warnings were not given when they ought to be.

The value to farmers of the bulletins, with explanatory notes issued for their benefit, has been very great, and so also the river reports have been of service to river commerce, and to the population in the vicinity.

The New York station of the signal service is away up on the roof of the immense building of the Equitable Life Assurance Company. It commands a superb view of the city and bay, and affords a place for the display of the cautionary signals where they are visible from all parts of the harbour. The lantern, displaying a red light, is 195 feet above sea-level; while the flag—red, with a black centre—floats from a staff at an elevation of 235 feet.

Here is the wind vane which needs no description. And here is the anemometer, used to determine the velocity of the wind. By electric connections with ingenious but not complex machinery, this is a self-registering instrument. The train of wheelwork makes and breaks an electric circuit, which registers itself on the paper revolving by clockwork on the recording cylinder.

There is in the New York office a self-registering barometer. It is a rare and splendid instrument. One of the cylinders, which are revolved by clockwork, gives the register of the barometric changes for a day, and the other for a period of fifteen days. As in the anemometer, the connections between the instrument itself and the recording cylinders are made by electricity.

Both to save time and expense, as well as to insure accuracy, the telegraphic reports of the service are made in cipher. These ciphers are easily and quickly read by means of a book arranged for the purpose. Here, for example, is the cipher report of the observation taken at New York on a recent day:—"York, Monday, Dead, Fire, Grind, Himself, Ill, Ovation, View;" which, translated, reads:—

York: New York (station).
Monday: 30·07″ (barometer corrected).
Dead: 29·90″ (corrected barometer for temperature and instrumental error.
Fire: 70° (thermometer)
Grind: 75 per cent. (humidity).
Himself: west, fair (wind and weather).
Ill: 6 miles (velocity of wind).
Ovation: ¼ cirrus clouds, calm (upper clouds).
View: 67° (minimum temperature during night).

The Signal Service is an exacting one of the men engaged in it. It is a means of almost incalculable benefit to the country. From "Old Probabilities" himself, down to the privates, to the men in comfortable quarters in the cities, and to the men who winter on Mount Washington or Pike's Peak, the thanks of the whole community are due for their tireless service. There is nothing equal to it in any other part of the world, and we may well be proud of it.—*The Operator.*

AN OLD STORY.

BY W. J. WILSON, F.C.S., M.S.T.E.

"The Telephone (see next page)" is a sentence which it is somewhat startling to find in a newspaper thirty-four years old. It is to be seen, however, in the *Illustrated London News* of 24th August, 1844, surmounted by a large picture representing an instrument not much unlike a large Bell's box telephone, standing on the deck of a ship, and being worked by a gallant Jack Tar of the period. On the "next page" is a descriptive article of which the following (omitting details of proposed code of signals) is a copy. It will be seen that the apparatus is not an electrical telephone, but the employment of *compressed air.* The *four* or *five-mile* range, and the proposed uses of the instrument are curiously suggestive of the very latest "Yankee notion." It appears, in fact, to be a musical "aerophone"—

"THE TELEPHONE; A TELEGRAPHIC ALARM.

"Amongst the many valuable inventions recently laid before the Lords of the Admiralty, that of 'The Telephone, or Marine Alarum and Signal Trumpet,' by Captain J. N. Taylor, R.N., is, perhaps, one of the most important; its objects being to convey signals to vessels at sea or in harbour, to transmit orders to and from forts and ships; to prevent collisions at sea, or on railroads; to transmit orders on the field of battle, from position to position, as an auxiliary to the duties of the aide-de-camp, or orderly, who frequently rides with important despatches in the face of an enemy in great haste and imminent risk; to inform engine stations in case of fire; for alarms in dock yards, &c.; and as a means of communication between the palaces and halls of the nobility and gentry, &c.

"The principle of the telephone is one of musical accord. Composed of four alternate notes, given out separately, played like those of the cornet, and prolonged while the finger remains on the note. The instrument is formed of a chamber, into which air is compressed through three or more alternate pumps, which are moved by a corresponding number of cranks, set in motion by a winch; and of a set of piston keys, with valved apertures, giving free egress to the compressed air, which, in its passage, acts upon a series of metallic springs, and produces the required sounds through four pipes or trumpets.

* * * * * * *

The Telephone No. 1 will convey signals four or five miles; and, as a fleet sailing in three columns will not extend over more than three miles, it will be sufficient for the guidance of the whole fleet, in foggy weather, by night or day. For fixed stations, light-vessels, lighthouses, preventive ports, &c., it is made the size of a large drum, with trumpet in accordance, and will convey signals in foggy weather six or eight miles; or, by unscrewing the trumpet, and applying a parabolic phonic reflector to it, the sound will be conveyed to a much greater distance.

"Ships or steamers passing each other, by giving the signals for 'helm to port,' &c., &c., would prevent those dreadful collisions and loss of life which frequently occur, either from indecision, the thickness of the fog, or other causes.

"As an alarm instrument, to be used on light-vessels, lighthouses, dangerous headlands, &c., the telephone is most important, as it will be the means of preventing the great sacrifice of life and property which so frequently takes place in foggy weather from the lights being invisible. Vessels would also be directed by it to the pier or harbour, and the height of the tide for entering conveyed to those in the offing. On railroads, too, it is of great importance as an instant signal for stopping the train, increasing the speed, or the approach of another engine may be given from the guard to the engineer.

"Another advantage of the above instrument is that it can be employed with a secret key, so that two persons in correspondence will understand the communication, while it remains unintelligible to others."

TELEPHONIC ALARUM.—As will be seen from our advertising columns, a simple and inexpensive apparatus of this description has been devised by Mr. Conrad W. Cooke.

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TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY (LIMITED).

The half-yearly general meeting of this company was held at the office, 38, Old Broad-street, E.C., on Tuesday, 9th July, 1878, Sir Daniel Gooch, Bart., M.P., in the chair.—The Chairman said that since the beginning of the year a contract was entered into with the Western and Brazilian Company consequent on the loss of the *Hibernia*, on the 22nd November, for 555 miles of cable, which has been laid on the Coast of America. The company has also entered into an arrangement with the Anglo-American Company, for the purpose of endeavouring to recover the 1866 cable, but no information of a definite character has, up to the present time, been received. Several hundred miles of cable have also been made for the Eastern Extension Company for different portions of their system, which will be laid by their own repairing ships. The company has also manufactured a considerable amount of cable for the Government, and the directors were hopeful of the continued prosperity of the company. After a few remarks in answer to Mr. Abbott, a vote of thanks was unanimously accorded to the Chairman, directors, and the management of the company, and the proceedings terminated.

EASTERN TELEGRAPH COMPANY (LIMITED).

The twelfth half-yearly general meeting of this company was held on Thursday, the 11th inst., at the Cannon-street Terminus Hotel, under the presidency of Mr. J. Pender, M.P.

The report of the directors, of which an abstract has appeared in *The Electrician*, was taken as read.

The CHAIRMAN, in moving the adoption of the report, reviewed its principal features, and said that in agreement with the Government of Turkey, they had laid a cable from Constantinople to Tenedos, 180 miles, and they were prepared to lay it thence to Salonica, 189 miles, and they believed this matter would be formally adjusted within three or four days. During the half-year ending with September, 1877, for a period of four-and-a-half months, the whole of the traffic with India passed over the company's cable, and the Indo-European line having been restored in August last, this circumstance was the cause of the large decreases of traffic they had had to publish for the months of May and June. The joint-purse agreement with the Indo-European Company came into operation on the 1st of September last, and so satisfactorily had it worked, that it was now proposed that the Persian Gulf Department of the Indian Government should become a party to it. This system in the Mediterranean and Levant was working very satisfactorily, and, with a trifling exception, throughout the whole of the cable system in these seas. They believed they had now made it understood that, although the head-quarters were in London, they were virtually an international telegraph company. They hoped, before long, to announce that a cable would be connected from Aden with Zanzibar, the Mauritius, and the Cape, and the Australian Colonies had decided on possessing a duplicate cable, from which the company would derive a largely increased traffic. He then referred to the course taken by Mr. Newton at the last meeting respecting the re-election of Baron d'Erlanger, and said the amendment moved by Mr. Newton on that occasion was rendered imperative by Article 81 of the company's Articles of Association, in addition to which Mr. Newton had no right to submit a motion, as he was only a preference shareholder.

Lord WILLIAM MONTAGUE HAY seconded the adoption of the report and the declaration of the dividend recommended, and the motion was carried *nem. con.*

The agreement between the Indo-European Telegraph Department of the Indian Government, the company, and the Indo-European Telegraph Company, was subsequently approved, and the usual complimentary vote to the chairman and the directors terminated the proceedings.

*** Some "Answers to Queries" have been received too late for insertion this week.

TELEGRAPH SHARE LIST.

Amount of Issue.	Amount of Share.	Paid on Share.	Company.	Reserve as per last Report.	Dividends calculated at rate per cent. per annum. 1875. %	1875. %	1876. %	1876. %	1877. %	1877. %	When Payable.	Prices. 1875. Highest.	1875. Lowest.	1876. Highest.	1876. Lowest.	1877. Highest.	1877. Lowest.
£3,254,580	Stock	100	P Anglo-American	Deferred receiving no dividend until 6 per cent. has been paid to Preferred.		year.	5	4†	3	5	† Div. 5 % per ann. for quarter ending Dec. 31, 1876, 2 % for quarter ending Mar. 31, 4 % for quarters ending June 30 and Sept. 30, 6 % for quarter ending Dec. 31, 1877, and 4 % for quarter ending March 31, 1878.	75¼	51½	68½	53	62½	52
1,872,710	Stock	100	Do. Preferred B		—	—	10	2	6	6		Crtd	1876.	93	75	88½	79
1,872,710	Stock	100	Do. Deferred A		—	—	Nil.	6	Nil.	4		Crtd	1876.	44	29	38	25½
1,300,000	10	All	Brazilian Submarine	120,000	5	5	5	5	5	5	Quarterly.	7¾	6	7½	5¼	6¾	5⅞
160,000	10	All	Cuba (Limited)	—	—	—	—	—	—	—	——	—	—	—	—	—	—
60,000	10	All	Do. 10 per cent. Preference	—	—	—	—	—	—	—	——	—	—	—	—	—	—
116,379	10	9	Direct Spanish (Limited)	—	—	—	—	—	—	—	——	—	—	—	—	—	—
58,430	10	All	Do. 10 per cent. Preference	—	—	—	—	—	—	—	——	—	—	—	—	—	—
65,000	20	All	Direct United States	Nil.	—	Nil.	Nil.	Nil.	Nil.	5	Quarterly.	13	7	11½	6¼	13⅝	9½
369,700	10	All	Eastern (Limited)	110,000	5	year.	5	5	5		*a*Jany., April, July, Oct.	8	6⅜	7½	5	8¼	6⅝
232,000	100	All	Eastern 6 per cent. Debentures	—	—	—	—	—	—	—	——	—	—	—	—	—	—
200,000	100	All	Do. 5 per cent. Debentures	—	—	—	—	—	—	—	——	—	—	—	—	—	—
700,000	10	All	Do. 6 per cent. Preference	—	—	—	—	—	—	—	——	—	—	—	—	—	—
1,997,500	10	All	Eastn. Exten. Australasia & China	125,404	5½	year.	5	year.	5	year.	*a*Jany., April, July, Oct.	8¼	7	7½	5¼	8	6⅞
320,000	100	All	Eastn. Exten. 6 p.c. Deben. (1875)	—	—	—	—	—	—	—	——	—	—	—	—	—	—
192,680	10	All	German Un. Tl. and Tst.	—	—	—	—	—	—	—	——	—	—	—	—	—	—
1,500,000	10	All	Globe Telegraph and Trust	Nil.	5	7 4-5	4½	7 5-6	3⅜	7 6-7	*b*Jany., April, July, Oct.	6¾	5⅜	5⅞	4¼	5¼	4½
,500,000	10	All	Do. 6 per cent. Preference		6	6	6	6	6	6	Jany., April, July, Oct.	10½	9¾	10¼	9¼	10½	9½
150,000	10	All	Great Northern	85,543	5⅝	year.	6⅝	year.	6⅝	year.	5 % intrm. Jan. 1, July 1. Final Dividend April.	11½	7½	9¾	7	8	7
			Shares to Bearer, or can be Regstrd.														
—	25	All	Indo-European	—	—	—	—	—	—	—	——	—	—	—	—	—	—
120,000	10	All	Mediterranean Extension (Lmtd.)	—	—	—	—	—	—	—	——	—	—	—	—	—	—
32,000	10	All	Do. 8 per cent. Preference	—	—	—	—	—	—	—	——	—	—	—	—	—	—
—	18	All	Reuter's (Limited)	—	—	—	—	—	—	—	——	—	—	—	—	—	—
65,000	10	All	West India and Panama	16,000	Nil.	Nil.	Nil.	Nil.	1	1	‡ Converted from a 10 % into a 6 % 1st Preference.	4¾	1⅝	2½	⅛	3⅜	1½
34,563	10	All	Do. 6 per cent. Preference		7/6ac	year.	10/ac	year.	6‡	6		12	9	11	7	11	7½
67,500	20	All	Western and Brazilian	7,793	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Half-yearly.	18½	9½	10⅝	4½	5¾	4½
$1,500,000	$1000	All	Western Union Telegraph 7 per cent. First Mortgage Bonds	—	7	7	7	7	7	7	May, November.	108	102½	109½	105	113	106
£1,030,000	200	All	Do. 6 per cent. Sterling Bonds	Redeeemable by annual drawings at par.	6	6	6	6	6	6	March 1, September 1.	93	86	98	89	101	94

a Year ends March 31st. Interim Dividend of 5 per cent. Final dividend in July. *b* Year ends July 18th. Final dividend in July.

COMPANIES.	CLOSING PRICES 10TH JULY.	BUSINESS DONE WEEK ENDING 10TH JULY. Highest.	Lowest.
Anglo-American	63¼, ¾	64½	63½
Do. B.	93, ¼	93½	92½
Do. A.	36¼, ¾	37	36½
Brazilian	6 15-16, 7 1-16	7	6 15-16
Cuba	9¼, ¾	9½	9½
Do. Ten per Cent. Preference	16½, 17	17	17
Direct Spanish	1½, 2	—	—
Do. Ten per Cent. Preference	9½, 10	—	—
Direct United States	14¼, ¾	14½	14½
Eastern	7¾, 8	8	7¾
Do. Six per Cent. Debenture	108, 110	—	—
Do. Five per Cent. do.	103½, 4½	—	—
Do. Six per Cent. Preference	11 13-16, 15-16	12	11¾
Eastern Extension	7¾, 8	7 15-16	7 13-16
Do. Six per Cent. Debentures	109, 111	109½	109½
German Union	8¼, ¾	—	—
Globe Telegraph and Trust	5 7-16, 9 1-16	5½	5½
Do. Six per Cent. Preference	10 15-16, 11 1-16	11½	10¾
Great Northern	8¼, ¾	8½	8½
Indo-European	19½, 20½	—	—
Mediterranean Extension	2¼, ¾	—	—
Do. Eight per Cent. Preference	9¼, ¾	—	—
Reuter's	10, 11	—	—
West India and Panama	2 7-16, 9-16	2½	2½
Do. Six per Cent. Preference	8½, 9	8½	8 13-16
Western and Brazilian	4¼, ¾	4½	4½
West. Union 7 p. Cent. 1st Mortgage	118, 120	119	118½
Do. Six per Cent. Sterling	102, 4	—	—

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NOTES.

Submarine Cables.—At the present time there exists in working order over sixty-two thousand miles of sumbmarine cable, in the hands of eighteen companies.

A Cable to the Cape.—A Bill has passed the second reading providing for the payment of an annual subsidy to any Company who will construct an electric telegraph connecting the colony with England.

The Duplexing of the Wheatstone Automatic Instruments.—It is stated that on a recent occasion 219 average messages were sent in one direction, and 139 in the other, in the space of one hour, by applying the duplex system to these instruments.

Utilisation of Waste Sulphate of Zinc.—When this salt is mixed with its equivalent of common salt, and dissolved in boiling water, sulphate of soda and chloride of zinc are formed. The former salt may be separated by crystallization; the solution of the latter constitutes Sir W. Burnett's Disinfecting Fluid.

Physiology and the Microphone.—Dr. J. D. Macdonald, F.R.S., contributes a paper to *Nature*, July 11, on "The Anatomy of the Organ of Hearing in Relation to the Discovery of the Microphone and Magnophone." Dr. Macdonald was led to consider this question from reading the papers on these subjects in our issue of May 25.

Cyprus.—In the map recently given by the *Daily News* of this island and the adjacent coasts, lines were marked which many readers mistook to represent cables actually laid. Cyprus is not telegraphically connected with England, but is connected by a short cable to the neighbouring coast of Asia. We hope ere long, however, to hear that this island, which is to play a prominent part in the history of the period, will be telegraphically united with Egypt and Malta, and therefore to England.

Electrolysis with Evolution of Hydrogen at both Poles.—E. Elsässer has repeated his experiments on Electrolysis, in which magnesium was used as the anode, and hydrogen was evolved at both poles. He confirms his previous results, which were called in question by Beetz, and shows that the relation between the volume of hydrogen evolved at each pole is independent of the strength of the galvanic current, and, within certain limits, independent of the strength of the solution.

Military Telegraphs for Cyprus.—Under the arrangement made by Dr. Lyon Playfair between the Post Office and the War Office, that two companies of the Royal Engineers should be employed on the postal telegraphs of the South of England, on Thursday last, at twenty-four hours' notice, twenty non-commissioned officers and sappers of the 22nd and 34th companies, Royal Engineers, were collected from a dozen places, and sent on board her Majesty's troopship *Simoon*, at Plymouth, for telegraph service in Cyprus.—*Echo.*

The Telephone.—At the sitting of the *Académie de Sciences* held on the 1st inst. M. Du Moncel presented a telephone based on the principle of the microphone, and independent of any magneto-electric effect. The microphone, he observed, had hitherto been considered only as a telephonic transmitter; it was not supposed that it could constitute a receiving apparatus, reproducing sounds transmitted by another apparatus of the same kind. But it has been found by Messrs. Hughes, Blyth, and R. H. Courtenay that a suitably-arranged microphone may be made to speak distinctly, though the sounds are not so strong as those obtained by the ordinary plan with a microphone and telephone. A battery of four Leclanché elements is sufficient to produce the effect.

Invention of the Telephone.—At the sitting of the Académie mentioned above, M. Du Moncel was desirous of communicating, on behalf of M. Baley, the representative of Mr. Elisha Gray, a note in which the latter gentleman claimed that the discovery of the speaking telephone belonged to himself, and not to Mr. Graham Bell. But, as the rules of the Académie do not allow the discussion of questions relating to patented inventions, the paper had ultimately to be withdrawn.

New Battery.—At the same sitting, Mr. Du Moncel presented to the *Académie* the single-fluid-atmosheric-depolarisation battery of M. Pulvermacher, noticed—for the first time—in our issue of the 6th inst. Its novelty in principle, economy in working, and extraordinary constancy—for a single-fluid couple—were very favourably mentioned.

The Electric Light.—It is somewhat over two hundred years since the first public lantern was put up in Paris—a lantern enclosing a candle. This was in 1668. Louis XIV. was so pleased with this innovation that he ordered a medal to be struck, with the legend, *Securitas mittor.* In our days the dazzling spectacle offered by the Avenue de l'Opéra is that which most excites the admiration of strangers. The application of the electric light is in Paris daily extending. Many large workshops and other commercial establishments have adopted it, and it is to be found at the termini of several of the railways. Besides the Avenue de l'Opéra, the Place de l'Opéra, a portion of the terrace by the banks of the river at the Tuilleries Gardens, the front of the old Chamber of Deputies, and the Place de l'Etoile, are illuminated by the electric light. Yet in London there is not one such light to be seen!

Following Nature.—Most of our readers know how closely Smeaton imitated Nature's design when he constructed Eddystone lighthouse, and many know how often we find our best designs foreshadowed by Nature's work. It is so even with a submarine cable. In a paper on the natural ropes used in packing cotton bales in the Brazils we find Mr. Bailey saying, "A still more remarkable example supplied by this family (*Sapindaceæ*) in the form of a natural rope is one which might have served our telegraph engineers as the model of a submarine cable. Like the Serjania, there is a central woody mass, possessing a medullary sheath and pith, woody layers, and a cortical system; but, surrounding this central core, and arranged parallel with it, is a series of eight lateral strands, each surrounded by its own bark, the whole being consolidated so as to form a rigid cylindrical axis, which presents no external manifestation of its peculiar internal organisation."

Magnetic Oxide of Iron.—H. Moissan *(Compt. rend.)*, in a paper on the Allotropic Modifications of this Oxide, says that the magnetic oxide of iron, obtained by heating its peroxide for some hours in hydrogen gas or carbonic oxide at 350—440°, or by heating the hydrate of the magnetic oxide at 300° in an indifferent gas, or by calcining the pyrophoric protoxide at a low red heat, passes into peroxide by calcination in the air, and is attacked by concentrated nitric acid. Its density is 4·86. Magnetic oxide obtained at a high temperature by burning iron in oxygen, or by decomposing the sesquioxide at a bright red heat, has a density of 5 to 5·09, and does not possess those properties. Pyrophoric protoxide of iron is transformed when heated in the air into peroxide; but, if this substance be heated to dull redness in carbonic acid gas, mag-

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netic oxide is obtained identical with the first variety mentioned above. If this variety be heated intensely in nitrogen the second kind—namely, that incapable of taking up more oxygen, is the product.

Colliery Explosions and the Microphone.—In a letter to *The Times*, Mr. Charles E. de Rance, C.E., writes:—"Professor Hughes has recently informed the Physical Society of the varied applications of practical value to which his remarkable invention, the microphone, has already been put. It has occurred to me its operations may be extended to the possible prevention of colliery explosions. All who have visited a fiery mine have listened to the peculiar hissing sound given out by pores and joints in coal-seams from which gas is being evolved, varying in intensity with the quantity delivered. Could not a combination of the microphone and telephone be constructed so that these sounds emitted underground may be reproduced in the colliery office, and a permanent record be kept by means of the phonograph? This, consulted every morning by the firemen previous to their daily inspection of the mine, would indicate not only to a certain extent the quantity of gas given off, but the exact part of the mine from which it has been given off; for several 'transmittors' might be placed in each coal seam, and a separate phonograph connected with each 'receiver' in the office. Should this be found practicable, the importance of daily telegraphic exchange of results is obvious, when it is remembered that the causes leading to extensive outbursts of gas at a particular colliery are experienced over a wide area."

Submarine Lamps.—The perfection to which the art of diving has been brought has necessitated the introduction of some means of enabling the diver to carry with him an artificial light. The fact is obvious that with a water-tight lantern an ordinary oil-lamp could be used, but that would involve a supply of air and a length of hose equal to that paid out to the man who carried it. To be of any practical utility, however, a diver's lamp should have the maximum power of illumination, and any suggested application of gas or oil falls short of what is needed. Under these circumstances two ingenious methods of lighting the bottom of the sea have been invented, and experience must decide which is the more successful. The first is an electric lamp, which appears to leave nothing to be desired in the matter of mere illuminating power, but doubts may be entertained as to whether the necessary connections with the battery would not interfere with the free movements of the diver, or, on the other hand, whether his movements would not disarrange them. The current necessary requires a large battery, and, unless that could also be submerged, connecting wires would be required, which would be liable to derangement by the motion of the vessel containing the battery. The lamp gives a light equal to 20,000 candles, and the arrangement of the carbons has been so improved that it would burn uninterruptedly for four hours. The other method consists in the use of a simple spirit lamp, fed by oxygen compressed in an iron cylinder. That arrangement has the advantage of allowing it to be taken down by the man and moved about as he pleases, for the oxygen bottle can be slung over his shoulder while he carries the lamp in his hand. The light is not so brilliant as that produced by electricity, but appears to be sufficient for all the wants of the diver.

On the Magnetic Rotation of the Plane of Polarization of Light under the Influence of the Earth. By Henri Becquerel.—In the course of my investigations on magnetic rotatory polarization I have been led to the direct estimation of the action of terrestrial magnetism upon various substances. This action can be very neatly made evident by an experiment which seemed to me sufficiently interesting to be communicated to the Academy. Between a Jellet polarizer and an analyzer furnished with a telescope and mounted on a divided circle is placed a tube of half a metre length, terminated by parallel glass plates and containing bisulphide of carbon. At the two ends of the tube plane mirrors, arranged as Faraday arranged them, gave several successive reflections of the luminous ray, and thus augmented the observed rotation. In the present experiment the second reflection could be viewed; the ray had therefore traversed the tube five times, corresponding to a thickness of 2·5 metres of bisulphide of carbon. The source of light was a pipe with oxyhydrogen gas. A great amount of light was lost by absorption and by the successive reflections, and the rays transmitted to the eye were chiefly the yellow rays. The entire system was firmly fixed to a horizontal copper rule, and could turn about a vertical axis so as to orient the luminous beam in various directions. With this arrangement it is ascertained that, if the system be made to coincide in direction with the plane of the magnetic meridian, the same position of the polarization-plane is not obtained whether we look towards the south or towards the north; a great number of closely concordant measures gave an angular difference of about 6′·5 between the two positions. On the contrary, if we place ourselves in a position perpendicular to the magnetic meridian, we get the same direction of the plane of polarization whether we look towards the east or towards the west, and this position is the bisectrix of that which we have in viewing towards magnetic north and south. It may hence be concluded that the angular difference observed is a rotation of the plane of polarization of the light, due to the action of the earth; the number 6′·5 measures the double of the rotation for yellow light and in the special conditions of the experiment. The direction of this rotation is the same as that of the rotation of the earth; it is the direction of an electric current which, on the hypothesis of Ampère, would give rise to the phenomena of terrestrial magnetism. It must be remarked that the number we have given only refers to observations made in the laboratory of the Muséum d'Histoire Naturelle, in proximity to more or less considerable masses of iron. To ascertain with more precision the action of the globe, and to utilize this method for estimating the intensity of the earth's magnetism, it would be necesary to use the same precautions as for ordinary observations of terrestrial magnetism, and to amplify the phenomenon by taking a longer tube. This is what I am at present engaged in. The system arranged as above indicated exhibits remarkable sensitiveness to the action of magnetism: an ordinary bar magnet held in the hand, and brought parallel near to the tube, first in one direction then in the other, is sufficient to make manifest a rotation of the plane of polarization that may attain to upwards of 1°. It is interesting to compare this direct measurement with an estimation made by Mr. Gordon* of the magnetic rotation produced by 1 centm. of bisulphide of carbon under a magnetic action equal to unity. The result found by calculating from this number the action of the terrestrial horizontal component is that 2·5 metres of bisulphide of carbon should give, with yellow light, a single rotation of 3′·8 instead of 3′·25, which results from our direct observation. The difference may be due to exterior perturbations. If we adopt the latter number we see that, under the conditions in which we have placed ourselves, the double rotation of 1 metre of bisulphide of carbon would be 2′·6, and that of 1 metre of water 0′·8.—*Comptes Rendus de l'Académie des Sciences*, April 29, 1878.

* 'Philosophical Transactions, 1877.' Part I.

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THE ABSOLUTE UNIT OF ELECTRICAL RESISTANCE.

BY PROFESSOR H. A. ROWLAND.

[CONTINUED FROM P. 87.]

Corrections.—Calling β and δ the scale deflections corresponding to tan. α' and sin. $\frac{1}{2}\theta'$, we may write our equation for the value of the resistance

$$R' = \frac{K}{T}\frac{\tan.\,\theta}{\tan.\,\alpha}\frac{\beta}{\delta}\frac{1 - \frac{1}{4}\left(\frac{\beta}{D}\right)^2 + \frac{1}{8}\left(\frac{\beta}{D}\right)^4}{1 - \cdot35\left(\frac{\delta}{D}\right)^2 + \cdot22\left(\frac{\delta}{D}\right)^4}(1 + A + \&c.)$$

where R' is the resistance of the circuit, at a given temperature 17°C., and $K = 2\pi M \frac{G}{G''}(1 + a + b + \&c.)$ in which A, B, &c., and a, b, &c., are the variable and constant corrections respectively.

a. Correction for damping, $a = -\frac{1}{2}\lambda + \frac{5}{12}\lambda^2$.

b. Torsion of fibre. The needle of the tangent galvanometer was sustained on a point, and so required no correction. The correction for the torsion in the other galvanometer is the same for β and δ, and hence only affects T. Therefore, if t is the coefficient of torsion, $b = -\frac{1}{2}t$.

c. Rate of chronometer. Let p be the number of seconds gained in a day above the normal time $c = -\frac{\phi}{86400}$.

d. Reduction to normal metre. The portion of this reduction which depends on temperature must be treated under the variable corrections. Let m be the excess of the metre used above the normal metre expressed in metres; then $d = + m$.

e. Correction of T for the arc of vibration. This arc was always the same, starting at c_1, and being reduced by damping to about c_n $e = +\frac{1}{128\,n\,\lambda}(c_1^2 - c_n^2)$ where c_1 and c_n are the total arcs of oscillation.

f. Correction for length of needles. For the tangent galvanometer the correction is variable. For the circle it is $f = +\frac{3}{4}\left(\frac{l}{A}\right)^2$ where l is half the distance between the poles of the needle and A the radius of circle. For the other galvanometer it is included in the formula for G.

A. Reduction to normal metre. As the dimension of R is a velocity, and the induction coils were wound on brass, the correction is $A = +\gamma(t' - t'')$ where γ is the coefficient of expansion of brass or copper, t' the actual and t'' the normal temperature.

B. Correction of standard resistance for temperature. Let μ be the variation of the resistance for 1°C., t''' be the actual and t^{iv} the normal temperature 17°C.; then $B = -\mu(t''' - t^{iv})$.

C. Correction for length of needle in tangent galvanometer. $C = +\frac{15}{4}\sin.(\alpha + \alpha')\left(\frac{l'}{A'}\right)^2(\alpha' - \alpha)$ where l' is half the distance between the poles of the needle and A' is the radius of the coil.

D. The resistance of the circuit was constantly adjusted to the standard, but during the time of the experiment the change of temperature of the room altered the resistance slightly; this change was measured, and the correction will be plus or minus one-half this. The resistance was adjusted several times during each experiment. The correction is $\pm$ D. Some of the errors which are compensated by the experiment need no remark, and I need speak only of the following.

No. 3. By the introduction of commutators at various points all mutual disturbance of instruments could be compensated.

No. 5. In winding wire in a groove it may be one side or the other of the centre. By winding the coils on the centre of cylinders, which set end to end, on reversing them and taking the mean result this error is avoided.

No. 6. The circle was always adjusted parallel to the coils of the galvanometer. Should they not be parallel to the needle, G and G' will be altered in exactly the same ratios, and will thus not affect the result. The same may be said of the deflection of the magnet from the magnetic meridian due to torsion.

No. 7. β and δ both ranged over the same portion of the scale, and so scale error is partly compensated.

No. 8. The zero-point of all galvanometers was eliminated by equal deflections on opposite sides of the zero-point.

Instruments.

Wire and Coils.—The wire used in all instruments was quite small silk-covered copper wire, and was always wound in accurately-turned brass grooves in which a single layer of wire just fitted. The separate layers always had the same number of windings, and the wire was wound so carefully that the coils preserved their proper shape throughout. No paper was used between the layers. As the wire was small, very little distortion was produced at the point where one layer had to rise over the tops of the wires below.* Corrections were made for the thickness of the steel tape used to measure the circumference of each layer, also for the sinking of each layer into the spaces between the wires below, seeing that the tape measures the circumference of the tops of the wires. The steel tape was then compared with the standard.

The advantages of small wire over large are many. We know exactly where the current passes; it adapts itself readily to the groove without kinks; it fills up the grooves more uniformly; the connecting wires have less proportional magnetic effect; and, lastly, we can get the dimensions more exactly. The size of wire adopted was about No. 22 for most of the instruments.

The mean radius having been computed, the exterior and interior radii are found by addition and subtraction of half the depth of the coil. The sides of the coil were taken as those of the brass groove. All coils were wound by myself personally to insure uniformity and exactness.

Tangent Galvanometer.—This was entirely of brass or bronze, and had a circle about 50 cm. diameter. The needle was 2·7 cm. long, and its position was read on a circle 20 cm. diameter, graduated to 15'. The graduated circle was raised, so that the aluminium pointer was on a level with it, thus avoiding parallax. The needle and pointer only weighed a grain or two, and rested on a point at the centre which was so nicely made that it would make several oscillations within 1°, and would come to rest within 1' or 2' of the same point every time. I much prefer a point with a *light* needle carefully made to any suspended needle for the tangent galvanometer, especially as a raised circle can then alone be used. The needle was suspended at a distance from any brass which might have been magnetic. There were a series of coils ascending nearly as the numbers 1, 3, 9, 27, 81, 243, whose constants were all known, but only one was used in this experiment. The probable error of a single reading was about $\pm$ 1'.

Galvanometer for Induction Current.—This was a galvanometer on a new plan, especially adapted for the absolute measurement of weak currents. It was entirely of brass except the wooden base, and was large and heavy, weighing twenty or twenty-five pounds. It could be used with a mirror and scale, or as a sine galvanometer. It will be necessary to describe here only those portions which affect the accuracy of the present experiment.

The coils were of the form described above in the theoretical portion, and were wound on a brass cylinder about 8·2cm. long, and 11·6cm. diameter, in two deep groves about 3 cm. deep and 2·5cm. wide. The opening in the centre for the needle was about 5·5cm. diameter, and the cylinder was split by a saw-cut, so as to diminish the damping effect. This coil was mounted on a brass column rising from a graduated circle, by which the azimuth of the coil could be determined by two verniers reading to 30''. Through the opening in the coil beneath the needle passed a brass bar 95cm. long and 2cm. broad, carrying a small telescope at one end. In the present experiment this bar was merely used in the comparison of the constant of the instrument with that of another instrument. For this purpose the instrument is used as a sine galvanometer, by which a great range can be secured, and it could be compared with a coil having a constant twenty-three times less, and which was used with telescope and scale.

The coils contained about five pounds of No. 22 silk-covered copper wire in 1,790 turns.

Two needles were used in this galvanometer, each constructed so that its magnetic axis should be invariable. This was accomplished by affixing two thin laminæ of glass-hard steel to the two sides of a square-piece of wood, with their planes vertical. This made a sort of compound magnet very strong for its length, and with a constant magnetic axis. The first needle had a nearly rectangular mirror, 2·4 by 1·8 cm. on the sides and ·22 cm. thick. The other needle had a circular mirror, 2·05 cm. diameter, and about 1 mm. thick. The needle of the first was 1·27 cm., and of the second 1·20 cm. long, and the pieces of wood were about ·45 cm. and ·6 cm. square respectively. The moment of inertia of both was much increased by two small brass weights, attached to wires in extension of the magnetic axis, thus extending the needles to a length of 4·9 cm. and 4·2 cm. respectively. The total weights were 5·1 and 5·6 grains, and the times of vibration about 7·8 and 11·5 seconds. They were suspended by three single fibres of silk about 43cm. long.

In front of the needle was a piece of plane-parallel glass. This and the mirrors were made by Steinheil, of Munich, and were most perfect in every way.

In the winding of the coils every care was taken, seeing that a small error in so small a coil would produce great relative error.

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And for this reason the constant was also found by comparison with another coil. The following were the dimensions:—

$$\text{Mean radius } 4{\cdot}3212 \text{ cm.}$$
$$R = 5{\cdot}6212 \qquad r = 3{\cdot}0212$$
$$X = 3{\cdot}475565 \qquad x = {\cdot}935565$$
$$R - r = 2{\cdot}6000 \qquad X - x = 2{\cdot}54000$$
$$N = 1790{\cdot},$$

whence

$$F = 1832{\cdot}25 - 1{\cdot}70\, b^2 Q_2(\theta) - 4{\cdot}50\, b^4 Q_4(\theta) + {\cdot}90\, b^6 Q_6(\theta) - \&c.$$

Taking the mean dimensions of the two needles, we have

$$l = 1{\cdot}23, \quad w = {\cdot}52, \quad n = \tfrac{1}{4}, \ \cos.\ \theta' = {\cdot}748.$$
$$Q_2(\theta') = + {\cdot}339, \quad Q_4(\theta') = - {\cdot}354, \quad Q_6(\theta') = - {\cdot}275.$$
$$\therefore G = 1832{\cdot}25 - {\cdot}083 + {\cdot}071 - {\cdot}002 + \&c. = 1832{\cdot}24.$$

The coil with which this galvanometer was compared was the large coil of an electro-dynamometer similar to that described in "Maxwell's Electricity," Art. 725, but smaller. The coil was on Helmholtz's principle, with a diameter of 27·5 cm., and was very accurately wound on the brass cylinder. There was a total of 240 windings in the coil. The constant of this coil was 78·371 by calculation.

To eliminate the difference of intensity of the earth's magnetism, an observation was first made, and then the positions of the instruments were changed so that each occupied exactly the position of the other: the square root of the product of the two results was the true result free from errors. The coils of the galvanometer could be separated so that an outer and inner pair could be used together. By comparing these parts separately and adding the constants together we find G. Hence two comparisons are possible, one with the coils together, and the other with them separate. The results were for the ratio of the constants 23·3931 and 23·4008, which give G = 1833·37 and 1833·98. The mean result is 1833·67 ± ·09, and this includes seven determinations with two reversals of instruments. This result is one part in thirteen hundred greater than found by direct calculation, which is to be accounted for by the small size of the galvanometer coils and the consequent difficulty of their accurate measurement. As comparison with the electro-dynamometer has such a small probable error, and as it is a much larger coil, it seems best to give this number twice the weight of that found by calculation; we thus obtain G = 1833·19 as the final result.

It does not seem probable that this can be in error more than one part in two or three thousand.

Telescope Scale, &c.—The telescope mirrors and plane-parallel glass were all from Steinheil in Munich, and left nothing to be desired in this direction, the image of the scale being so perfect that fine scratches on it could be distinguished. The telescope had an aperture of 4cm., and a magnifying power of 20 was used. The scale was of silvered brass, one metre long, and graduated to millimetres.

Induction Coils.—A coil was wound in a groove in the centre of each of three accurately-turned brass cylinders of different lengths. Two of them only were used at a time by placing them end to end, the ends being ground so that they laid on each other nicely. The two coils could be placed in four positions with respect to each other, in each of which they were very exactly the same distance apart. This distance for each of the four positions was determined at three parts of the circumference by means of a cathetometer with microscopic objective, reading to $\frac{1}{20}$ mm. The mean of all twelve determinations was the mean distance. In using the coils they were always used in all four positions. The probable error of each set of twelve readings was ± ·001mm. The data are as follow, naming the coils A, B, and C:—

Mean radius of A = 13·710, of B = 13·690, of C = 13·720. Mean distance apart of A and B = 6·534, of A and C = 9·574, of B and C = 11·471. N = 154 for each coil, $\xi = {\cdot}90$, $\eta = {\cdot}84$. For A and B we have $M = 3774860{\cdot} + \frac{1}{12}(74250{\cdot} - 66510{\cdot}) = 3775500{\cdot}$. The remaining terms of the series are practically zero, as was found by dividing one of the coils into parts, and calculating the parts separately and adding them. For A and C $M = 2561410{\cdot} + \frac{1}{12}(34000{\cdot} - 27230{\cdot}) = 2561974{\cdot}$. For B and C $M = 2050600{\cdot} + \frac{1}{12}(27500{\cdot} - 19800{\cdot}) = 2051320{\cdot}$. The calculation of the elliptic integrals was made by aid of the tables of the Jacobi function, q, given in Bertrand's 'Traité de Calcul Integrale,' as well as by the expansions in terms of the modulus after transforming them by the Landen substitution.

[TO BE CONTINUED.]

GENERAL CONSIDERATIONS UPON TELEGRAPHIC TARIFFS.*

In 1875 the delegates of the Administrations constituting the European Telegraphic Congress met for the fourth time.

The St. Petersburg Conference, opened on the 1st June, was closed on the 19th July. This period of seven weeks, taken up by twenty full sittings and numerous meetings of three committees appointed for the first elaboration of the work, ought to astonish those who see in the telegraph only a mechanical operation, always the same, having for its sole object the transmission and interpretation of signals. The programme of the Conference was not confined within any such restricted limits. Independently of the new form given to the Convention and to the regulation of service, according to the vote of the Rome Conference in 1872, the delegates occupied themselves at St. Petersburg with numerous propositions relating to all the details of the service of correspondence.

There were 347 such propositions, of which 157 were adopted, 56 rejected, and 134 withdrawn after preliminary discussion.

This was not the only nor the most important work. Tariffs were the object of long discussions, not merely as to the distribution and adjustment of the charges, but from the point of view of the bases of taxation (tarification). These bases had been little debated since the first International Telegraphic Conventions, which go back to 1850.

The general feeling that telegraphy ought not to be a source of profit for Governments, the desire to increase the correspondence by granting it the most favourable and uniform conditions, had been the sole guides of the Administrations, who, by successive reductions of tariff, had opened their systems to a very large number of messages without occupying themselves with anything beyond the means of despatching them. This generous impetus has brought the majority of the telegraph services of Europe to their present position, which may be described in the following terms:—

The interior correspondence of each state causes a loss, the internal telegram having the minimum of charge with the maximum of net cost.

The international correspondence produces profits. But as the first is more susceptible of developing year by year than the other; as, moreover, the expense gradually increases by the increase in the price of everything, and by the constant necessity to improve the service, the amount of expenses is no longer covered by the revenue.

What is the remedy for this state of things? Can or ought the Government to apply it?

These questions were only examined at St. Petersburg from the point of view of propositions which related to the tariff. They could neither be studied nor determined completely; but this study will be necessary before long, and it appears to us useful to have the elements of it prepared by preliminary examination of the general principles which it follows.

In endeavouring to develope these principles we are liable on the one hand to reproduce solutions already known, and on the other to put forth opinions open to dispute. These two rocks do not alarm us. We see still manifesting themselves at one time or other absolute faith in the benefit of competition, horror of monopoly, the hope of increasing profits by the reduction of charges, &c. It is not then useless to reproduce known facts which reply to these illusions. As to the mistakes with which we may be reproached we shall not regret them if they are worthy the honour of being discussed and the advantage of being corrected by the discussion.

1. *Is telegraphic monopoly justifiable. Within what limits and for what reasons?*

This question relates naturally to the monopolies which exist, or have existed in fact, or by right.

If there were produced anywhere a monoply having for object or result to obtain from telegraphic correspondence the maximum of profit to the detriment of the public, restraining the developement of this correspondence and the direct and indirect benefits flowing from it, it would be necessary to combat this monopoly. All the resources of economical science would not be necessary to condemn it.

The Government monopoly which has existed in Europe for a quarter of a century has no resemblance to this phantom. To prove this it suffices to recall the financial results cited. But, it is alleged that Government intervention is essentially unfruitful and expensive, that it does not favour invention, nor economical progress tending to abate the net cost. It is true that the operations of transmission upon terrestrial or submarine telegraph lines are due to English or Anglo-American inventors, but it would be rash to seek the source of this superiority in the

[* Translated from the *Journal Télégraphique*.]

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single fact that, telegraphs were at first in the hands of private companies in the United Kingdom, and are still so worked in the great Republic of North America.

It is more rational to see the cause of it in the spirit of initiative and enterprise which has given telegraphs to the public of these two nations, before this mode of correspondence was considered practicable, or demanded upon the European continent.

Let us not forget, moreover, that the Morse and Hughes instruments have found in the telegraph administration of Europe an earnest reception, and the principal practical improvements which have brought them to their present degrees of perfection.

As to the expense, this results especially from the non-productive extensions which governments impose upon themselves in order to make a very large number of secondary localities, where the traffic, necessarily very limited, does not cover the cost of the service, to participate in the benefits of correspondence. It is precisely this which renders monopoly equitable and necessary.

An administration forced at the same time to work unproductive lines and to submit to competition upon productive lines, could not exist. To prove this from examples of competition, it is necessary to find what passed in England before the purchase of telegraphic enterprises by the Government, and in the United States before the fusion of the rival workings.

Competition arose upon certain lines, and caused reduction of tariff upon these lines only. The soundest enterprise ended by absorbing the other. After this combination the tariff was raised, not only because competition had ceased, but because the victorious system had nearly doubled its local charges in acquiring the other line. There was benefit neither for the public nor for the shareholders.

It was with the approbation of commerce, the Press, economists, and the public in general that the British Government bought and completed at the enormous price of 225 millions of francs the telegraphic lines composing the present system of the United Kingdom.

The Records of Public Works reproduce long extracts from the report of the parliamentary inquiry which preceded this important measure.

We repeat here only this passage of the testimony of Mr. Stanley Jevons, Professor of Political Economy at the Manchester College—a declared opponent to monopoly in general:—

"Really we possess neither the advantages of monopoly nor those of free competition.

"I see no other chance of improvement but monopoly; consequently I would rather see this monopoly in the hands of the Government than in the hands of a private company."

An analagous movement took place in the United States at nearly the same time. The propositions submitted to Congress by the Postmaster-General did not come to anything, but they had for their object the intervention of the Post-office, by right of competitor, in the existing lines, and without purchasing them, as in England. Whatever might have been the result of the propositions of the Government, the arguments contained in its report, of which we produce some extracts, are not a little characteristic.

"The country will be delivered from a monopoly which weighs upon the public—a monopoly which almost tries to control the daily Press. . . . The telegraph is relatively less employed here than in Belgium and Switzerland; its use is limited to a certain class of affairs, the high tax being considered prohibitory for certain categories of affairs and for certain classes of the population.

"The tariffs are arbitrary and exhorbitant, varying for the same distance, according to the lines, often higher for a nearer station upon the same line."

Let us cite an estimation, more pertinent still, of a technical American journal, *The Telegrapher*, referring to the great competition of 1850, when there were eighty to ninety telegraphic companies in the United States.

"Each new enterprise has been projected and conducted by a band of mongers without principle, whose principal object is to fill their pockets at the expense of credulous shareholders. When the lines are working, and it is seen that the expenses largely exceed the receipts, they hasten to throw the blame upon the unfortunate adminstrations, whereas the latter do their best to obtain a traffic upon lines out of order and unworkable, which have been saddled on to them by the shameless speculators."

Governmental monopoly is justified, then, as much by the example of countries where it obtains as by the necessity of finding resources in paying lines to make it possible to extend the institution to those parts of the country where it cannot produce any profit.

This justification ceases to be applicable when private interest shows itself disposed to extend the means of correspondence to certain localities or branches, of which monopoly is not disposed to take charge.

It is for this reason that the Austrian Government has granted to a company the working of a special telegraphic system which connect the different quarters of Vienna. Thus, also, the Belgian Government proposed to the legislature a law authorising it to grant to private parties concessions for local telegraphy under similar conditions.

2. *Is monopoly always a cause of increase of tariff, and is competition always a cause of cheapness?*

We will still cite facts. In England, the introduction of real monopoly has been accompanied by a uniform charge for the three kingdoms equal to the minimum of the inland tariffs, excepting some local relations.

In the United States of America, the competition of the 80 to 90 companies above mentioned has placed in the hands of the Western Union Company almost the whole traffic of the country. None of the European Counties possesses so important a system, but it appears to us interesting to compare the results obtained by this immense working from the 1st July, 1874, to the 30th June, 1875, and the position of its lines at this latter date, with the corresponding figures applying to all Europe.

This latter information is only known to us for the period 1873, but the comparison is not less interesting, the general conditions of European telegraphy not having sensibly varied from 1873 to 1875.

Moreover, the importance of the lines and of the business of all Europe (the internal services included) is equivalent to nearly three times that of the Western Union Company, and we have divided the first figures by three to make the comparison more salient:—

	Europe kil.	1-3d. of Europe. kil.	Western Union Co. kil.
Length of lines worked ...	331,079...	110,360...	117,188
Increase of conducting wires	912,109...	304,036...	288,494
Mean No. of wires per line	2¾	2¾	2½
No. of telegraphic offices ..	22,505...	7,502...	6,565
Total No. of telegrams ...	60,027,503...	20,009,167...	17,153,710
Mean No. per office	2,667...	2,667...	2,613
	Fr.	Fr.	Fr.
Total receipts	110,500,112...	36,833,371...	49,353,205
Mean product per message.	1·84	1·84	2·88
Expense of working and maintenance	105,140,792...	35,046,931...	32,690,740
Mean expense per message.	1·75...	1·75...	1·91
Excess of receipts	5,359,320...	1,786,440...	16,662,464

There is a great analogy between the two systems in regard to the number of conductors per line, but especially in regard to the mean business per office. The third part of the European system is in regard to importance the equivalent of the system and traffic of the Western Union.

The net receipts per message are 9 per cent. higher in America. It is true that the working is dearer there, but on their part the European Governments generally devote to official telegraphy or to the free correspondence of railways, expenses from which the Western Union Company is exempt. Be that as it may, there is nothing to cause one to suppose that this company works more economically than the European administrations.

The "mean product" is 56½ per cent. higher in America than in Europe. However, the European traffic considered comprises a very large number of international telegrams, the charge for which is divided between several services, which would justify a higher tariff. The net profit of the Western Union amounts to more than 16,000,000 francs, whilst it only attains 1,800,000 francs in Europe on a traffic nearly equal.

It may, perhaps, be alleged that the American system does not represent competition, the Western Union exercising upon almost all its lines an actual monopoly since it absorbed the greater part of the other enterprises.

But the previous state of things did not work well for the public, excepting during the short intervals of competition *à outrance*. Let us give a recent example, printed in the last report of the President of the Western Union Company, relating to the only rivalry that it still encounters:—"In the month of February last (1875), the Atlantic and Pacific Company having reduced to a uniform sum of 25 cents (1 fr. 29) the charges between Boston, Albany, Washington, and intermediate stations, the Western Union Company made a similar reduction in its tariff the same day. But, after having been in force for about six months, the reduced taxes were repealed, in accordance with an arrangement between the two companies, and the old rates were re-established."

This confession is free from all artifice, and, indeed, things could not be otherwise. Competition can only be produced by the co-existence of two or more enterprises in the same localities —a position which is bound to lead to the ruin or combination of these enterprises.

[TO BE CONTINUED.]

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HOW TO GET ON IN THE TELEGRAPHIC SERVICE.

We dwelt lately on the sound, Scriptural, and good old English doctrine, that whatever a man finds to do he should do it with all his might, nor waste his energies in grumbling that other people have what seems a more agreeable or less toilsome task. But we are not to be understood as preaching after the manner of those Conservative parsons in whose eyes it is almost the unpardonable sin for a man not to be stupidly content with that position in life which our social arrangements have assigned to him. Our view is that it would be well if every man knew what he was fit for, and did his best to raise himself to a position where his capabilities would become evident to others, a position most likely to be attained by the man who, while qualifying himself for the higher, in the meanwhile conscientiously fulfilled the lower duties that fell to his share. The man who can work with his head ought to work for us with his head, while he to whom brains have been denied, if it were the Lord Tom Noddy himself, should have to dig when he can no longer beg for his livelihood. And, with the leave of all the orthodoxies and gentilities, something like this is what we are fast coming to in that orderly developement of the heterogeneous which Mr. Herbert Spencer shows us to be the true growth of society.

In England, as yet, let us confess, most careers are not yet fully opened to talents; and among telegraphists, hastily taken as they have been from different classes for the performance of various duties, and scarcely having had time or means to organise themselves into a coherent body, it would be wonderful if the tools were always found in the hands best able to use them. In America, to which we must still look for instruction in the developement of practical science, merit has more chance of success. Here, such men as FARADAY, or EDWARDS, the Banffshire naturalist, are taken for singular phenomena; there it seems a matter of course that a FRANKLIN, or a JOSEPH HENRY should be "self-made" men—our aristocratic language, it will be noted, still wants a neat word to express the sense of *parvenir.* It is remarked that in the American telegraph service the highest officials have commonly risen from the lowest ranks. We think we can see how this comes to be so when we examine such a paper as the New York *Journal of the Telegraph.* We are bound to admit that, in some respects, our contemporary has the advantage. It evidently appeals with confidence to a wide circle of readers among the lower as well as the upper ranks of the telegraph service. The correspondence and queries of its readers show that they are aware of the benefits to be derived from such an organ. A list of marriages of telegraph agents and operators indicates the existence of a desirable *esprit de corps*, while the report of a "Telegraphers' Mutual Benefit Association" exhibits this feeling in a practical form. A goodly array of advertisements proves that "live" firms find their account in bringing the latest scientific works and apparatus under the notice of a public on the look-out for such advantages. It is quite clear that the man who subscribes to such a paper, who takes a thorough interest in its scientific contents, and who is helped by it to think of himself as belonging to a great and growing profession, is more likely to get on than the telegraphist who accepts his occupation as mere mechanical drudgery and has no higher ambition than to become a smart manipulator.

We hope to make our columns all that any other electrical paper is, and more, but our success must mainly depend on our readers. It is our interest as well as theirs that the thousands of telegraphic officials in Great Britain should be actuated by a healthy desire to rise in and to raise their calling. It may be that too little notice is taken of merit, and that superior posts are as yet too much given to men who in youth could afford superior advantages of general education. But in telegraphy there is an unusually narrow field for favour. As yet we have no superabundance of skilful electricians, and a man who has mastered both the theory and the practice of his work will not have to look long for employment. Our profession—if we may call it so—is one where experience and knowledge are absolute necessaries. It may do to appoint priggish boys as inspectors of schools or to send wealthy ignoramuses to Parliament as representatives of the national wisdom. Our batteries, however, must work; and the captains of electrical enterprise will soon betray themselves if they are unfit for their duties. Nor is the telegraphic private always serving in the ranks of a great army, as it were, where mere drill will carry him through his duties. On foreign stations he may be posted as a vidette, obliged to think and act for himself on emergencies. A cable may have broken down, and the "dead earth" may be close to the station, and where the fault might and should be repaired at once, after being accurately localised by means of a simple but skilfully-applied test. Or the station may run short of sulphate of copper for the batteries, and the operator may have the opportunity of showing that this salt may readily be manufactured with metallic copper and sulphuric acid, or that a Daniell battery may be converted into a Wollaston by means of the acid and a little mercury, or into the old sand-battery by means of the acid alone. Add that telegraphy is growing more and more scientific and complex, as new discoveries direct us to new modes of utilising electricity, and is, therefore, likely to require before long a class of operators whose qualifications rise above the

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mechanical and empirical. Surely, it is worth the while of any telegraphist not only to perfect himself in the practice of his art, but to study its principles, and to do all he can to fit himself for any post in the service.

The telegraphic world is as yet in a somewhat chaotic state; but we would have no youngest recruit unmindful of whatever in it answers to that field-marshal's *bâton* which every French conscript is proverbially said to carry in his knapsack. We promise heartily to respond to any disposition that may be shown on the part of operators to better themselves by such educational aid as we can give. And, with more reason, we re-echo the words of our Transatlantic contemporary :—"The telegraphist who only knows how to manipulate the key and read telegraphic signals as they are received, must be content with the lower and less remunerative positions, and has no right to complain if the more intelligent, studious, industrious, and therefore better qualified are preferred before him."

STUDENTS' COLUMNS.

ON SOME FORMS OF ENERGY AND THE CONNECTION BETWEEN THEM.

BY GEO. SMITH, B.SC.

We are all familiar with the motion of a body of sensible magnitude, as a whole, and we naturally employ the same terms in speaking of the motion of a very small body, as a whole, or of the motion of the very small portions of which bodies consist. When, by our senses, we perceive a body to occupy different positions at the commencement and end of a period of time, however small or large that period may be, we say that the body has moved. The motion may be a simple translation of a body from place to place, as in that of a sledge or of a falling stone; or it may be simple oscillation, or movement to-and-fro, as in that of a vibrating rod or tuning-fork; or it may be by simple rotation, as in that of a wheel on its axle or a spinning-top. Finally, the motion may consist of complex combinations of these, as in a rifle-bullet, a rolling billiard-ball, the moon, &c. In all these cases, the motion is supposed to consist in that of the body, as a whole, and hence it may be called molar motion.

If a piece of caoutchouc be stretched in the direction of its length, it is found to become longer, and, at the same time, its breadth and thickness diminish; although the caoutchouc itself may be said not to have moved bodily, still, motion of some kind must have occurred, the particles of which the caoutchouc consists must have glided or flowed over one another. In a similar manner, in gold-beating, wire-drawing, metal-spinning, and flowing water, the particles or molecules of the several bodies must glide or flow over one another. On rubbing a brass rod in direction of its length, we make its particles move, not by gliding, but in oscillation or vibration, which may be proved by its throwing off a small ball, suspended by a fine thread so as to touch its end. Sound is also produced in this case, and we may say generally that, in all cases in which sound is produced or propagated, this vibration of molecules is set up. If a metallic rod is heated, it is found to have increased in length, breadth, and thickness. Evidently, motion must have taken place among the particles of the rod. In these and similar cases, the bodies may occupy the same position, but the particles or molecules move; hence this kind of motion is termed molecular motion.

That which produces or tends to produce motion of any kind in a body is termed a force; in common life, however, the word force is used in a very loose manner; it has, therefore, been deemed expedient to replace it by a word the meaning of which shall be restricted to this sense. That word is energy. Energy, then, produces or tends to produce molar or molecular motion, and it may be measured by any recognised standards, by the work it is capable of performing. The energy which is actually wrapped up in moving matter, owing to which its motion will continue unchanged (unless changed by some exterior circumstance), is termed its actual or *kinetic energy*. On the other hand, that energy which tends to produce motion or is about to produce motion in matter is termed its *potential energy*.

We may examine energy under three heads :—

1st. As to kind or *quality*, which may be compared to the different kinds of liquids, the following are the most important :—Gravity, sound, chemical attraction, heat, light, electricity, and magnetism.

2nd. As to *quantity*, which may be compared to the volume of a liquid, as work, momentum, quantity of heat and electricity.

3rd. As to *intensity*, which may be compared to the height or head of a liquid, as weight, temperature, tension.

If we allow a body to fall, it will always fall in a determinate direction to the earth, in the line of action of the attracting energy; these lines are perpendicular to the horizon, and are termed *lines of force*. The energy of attraction of gravity varies, *cœteris paribus*, inversely as the square of the distance between the centres of gravity of the masses between which the attraction is exerted; thus we see that the energy of attraction exerted between the earth and another body must vary with the position of this body. This attraction may be measured in various ways; by the weight of a given mass ascertained by a spring balance, by the motion of a given pendulum, or, better still, by the work required to be done in order to remove a unit of mass to an infinite distance from the earth, *i.e.*, out of the sphere of attraction of the earth. This quantity of work is termed the *potential* of a body at that point.

It is obvious that the same amount of work would be required to remove a unit of mass from the centre of the earth to an infinite distance in any direction. Therefore, on subtracting the potential of a body from this total quantity, we obtain its absolulute potential energy, *i.e.*, the work it would perform in falling from that point to the centre of the earth; thus a body at a lower potential possesses more potential energy, and tends to fall from a position of lower to one of higher potential. All points at the same potential together form a surface, which may be termed an *equipotential surface*, and we may state that the same body at all points of an equipotential surface possesses the same potential energy. When the sea is smooth its surface forms an equipotential surface, for each particle is in equilibrium with its neighbours, and this is brought about by the attraction exerted by the earth, moon, sun, and to a much smaller extent by other heavenly bodies. As the relative attractions of these change with their position, so will the equipotential surface change, and so produce tides. If a body be suspended by a string at a distance above a horizontal, *i.e.*, equipotential, surface, it has a lower potential than it would have at the surface, and has a certain amount of potential energy in respect to this surface, which is represented by the work it would do in falling to it. This work is generally represented by its weight in pounds multiplied by its height in feet, this product being denominated foot-pounds. Thus, if we raise a body weighing 10lbs. through a height of 139 feet, we expend 1,390 foot-pounds of energy, and the body thus raised may be said to have 1,390 foot-lbs. of potential energy in respect to the surface from which it was raised. Now allow the body to fall. As it falls, it continually loses potential energy, until when it reaches the surface it possesses none. What has become of this potential energy? It has been converted into actual energy, the energy of a moving body, so that on reaching the surface it possesses 1,390 ft.-lbs of actual energy. If the body fall on a spring, then, neglecting friction, when it comes to rest it will have performed work represented by 1,390 ft.-lbs. The spring now possesses this 1,390 ft.-lbs. of potential energy, and, if this were allowed to expend itself in raising the body, it would raise it to its original height. We thus see that when a body performs work it loses energy; when work is performed upon it, it gains energy; and that when no work is done no energy is gained or lost.

If a body move along an equipotential surface, as along a smooth horizontal table, no work is done upon or by the body, for, as the two points are at the same equipotential surface, the potential energy of the body is unchanged, and the work expended in setting the body in motion is still in the body as actual energy and unchanged in amount. The intensity of gravity is represented by the velocity it will generate in a falling body in one second of time; at the earth's surface it is about 32ft.; and, as a mass of 1lb. is said to weigh 1lb., we see that a continuous pressure of one pound produces in one pound of matter an acceleration of 32ft. per second. If the 1lb. of matter be now moved to 4,000 miles above the earth's surface, *i.e.*, to double its former distance from the earth's centre, where the intensity of gravity is only one-fourth its former intensity, the attraction of gravity will only produce an acceleration of 8ft. per second, and the one pound of matter will weigh only a quarter of a pound. Thus a continuous pressure of ¼lb. produces in 1lb. of matter an acceleration of 8ft. per second. We may, therefore, connect continuous pressure or weight with mass, and the acceleration it produces in it. Thus, if W=pressure, m=mass, g=32, and f=acceleration produced in one second,

$$W = \frac{f}{g} m. \quad \text{. . . . . I.}$$

We know the quantity of work Q required to raise a body whose mass is in pounds through a height h; we also know through what height h a body must fall to acquire a given

velocity v; hence we may find the actual energy of a body of mass m moving with a velocity of v feet per second.

$$Q = m\,h, \quad v^2 = 2\,g\,h. \quad \therefore h = \frac{v^2}{2g}$$

$$\therefore Q = \frac{m\,v^2}{2\,g} \text{ foot lbs.} \quad . \quad . \quad . \quad \text{II.}$$

Thus a cannon ball, whose mass is 139lbs., and whose velocity is 80ft. per second, will have an amount of actual energy represented by $\frac{139 \times 80 \times 80}{2 \times 32} = 13{,}900$ft.-lbs.

If two moving bodies strike one another, and in doing so come to rest, their actual energy will seem to have disappeared. Their molar motion evidently has ceased; has their molecular motion undergone any change? If we could have tested the bodies with a thermometer just before and just after impact, we should have found that their temperature had risen; in fact, their actual energy of molar motion has been changed into that of the molecular motion of heat. Intensity of heat or temperature is measured by the various forms of thermometers; two fixed and easily attainable temperatures, as those of freezing and boiling water, are taken, and the difference is divided into a certain number of divisions called degrees. In the centigrade scale, the temperature of freezing water is marked 0° and that of boiling water 100°; the divisions between these, continued below 0° and above 100°, mark the corresponding temperatures. On raising the temperature of a body we evidently impart energy to it, and the quantity of energy so imparted is measured in thermal units by the mass of water in pounds which that energy can raise in temperature from 0° to 1°, or more roughly by the mass of water, in pounds, multiplied by the number of degrees of temperature through which it has been raised. Now, it must not be supposed that the intensity of heat expresses the quantity, even for the same substance, and for different substances it varies immensely. Thus it requires one thermal unit to heat one pound of water from 0° to 1°, but rather more than one thermal unit to heat the same pound of water from 99° to 100°; and to raise one pound of mercury from 0° to 1° requires only about one-thirtieth of a thermal unit. If it require T thermal units to raise the temperature of $m$lbs. of water through t°, then s its specific heat or capacity for heat, may be obtained from the formula.

$$s = \frac{T}{m\,t}. \quad . \quad . \quad . \quad . \quad \text{III.}$$

The greater part of the heat in all bodies exists as actual energy; for a heated body is continually radiating heat, *i.e.*, motion in all directions, and to do that must be in motion itself.

Suppose a quantity of air enclosed in a vessel and heated, say from 0° to 141°. A certain number of thermal units are required to do so; the heat is sensible to a thermometer, and exists, most probably, wholly as actual energy. Now, without heat being communicated to or from the air, suppose it be allowed to expand. As it expands it will be found also to become colder, until when expanded to its utmost, *i.e.*, when at its first pressure, its temperature is only 100°. As we suppose that no heat escapes during this experiment, and yet the temperature has fallen from 141° to 100°, we are naturally led to enquire what has become of the heat energy apparently lost. The air in expanding has performed work; some actual energy has been potential, the particles of air having become more distant from one another; and work may be expressed either by the number of thermal units lost by the air in cooling from 141° to 100° or by the number of foot-pounds expanded in raising the atmosphere during the act of expansion. Here we see that there is a connection between thermal units and foot-pounds, in fact if the air lose one thermal unit the atmosphere will have been raised by the expenditure of 1,390 foot-pounds of work, one thermal unit of molecular energy will have been converted into 1,390 foot-pounds of molar energy.

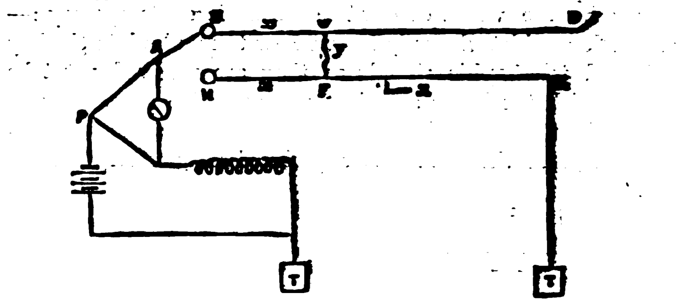
If a cannon ball whose mass is 139lb., travelling at the rate of 800ft. per second, comes to rest on striking a target, we may determine the amount of heat produced when the molar energy is converted into molecular. On referring to equation II. we see that the actual energy of the cannon ball is $\frac{139 \times 800 \times 800}{2 \times 32}$ $= 1{,}390{,}000$ foot-pounds, and this is equal to $\frac{1{,}390{,}000}{1{,}390} = 1{,}000$ thermal units.

[TO BE CONTINUED.]

ANOTHER METHOD FOR DETERMINING THE POINT OF CONTACT OF TWO WIRES.

When two wires touch at a point and the contact is perfect, the locality of the fault may be easily determined. It is enough to measure, with the further extremities insulated, the resistance of the contact formed by the two wires. The distance of the fault from the station whence the experiment is made is given, as is well known, by the half of said resistance divided by the mean resistance of the wire per kilometre.

If the contact offers resistance, as very often happens, this resistance must be eliminated. To do this, as far as I know, there have hitherto been employed three methods:—1. The Bridge method; 2. Schwendler's; 3. That with the differential galvanometer, as given by Culley. Each of these methods has obvious advantages and disadvantages, but the following method, devised by me, seems to be not only very simple, but is independent of the apparatus that may be used to measure the resistance.



Let B D, H E be two wires which are in contact at the points C F, one wire being insulated at its extremity, the extremity E of the other wire being put to earth. Connect with the apparatus you adopt to measure the resistance the point B of the first wire and measure the resistance B C F E, which we may call R. Then L = R — y (α) where L is the normal resistance of the line and y the resistance which the contact offers.

This done, connect the point A with the other wire at H, and again measure the resistance, which will naturally prove less than at first, since the circuit is a derivation of the former one. This resistance will be composed of the two parallel derived circuits B C F, H F, and the resistance F E. Calling this r, we shall have $r = \frac{(x + y)x}{2x + y} + L - x$ (β)

Substituting in this equation the value of y in the former, simplifying and arranging, we have

$$x^2 + 2(r - L)x + R\,r - R\,L - r\,L + L^2 = 0;$$

whence $x = L - r \pm \sqrt{r^2 - R\,L - R\,r + LR}$ (γ),

in which + must be taken, because from (β) we have

$$x = L - r + \frac{(x + y)x}{2x + y},$$

and as the quantity $\frac{(x + y)x}{2x + y}$ is always positive to L — r, we must add the root.

The formula to determine the distance of a contact between two wires may therefore be written

$$x = L - r + \sqrt{(L - r)(R - r)}$$

Example.—Let 280 be the normal resistance of each of the two wires, which, for simplicity, are supposed to be of equal diameters; 320 the resistance when only one, and 248 when both the wires are united to the point A, as mentioned above. We shall have

L = 280.
R = 320. L — r = 32.
r = 248. R — r = 72.

Applying the preceding formula we find

$$x = 32 + \sqrt{32 \times 72} = 32 + 48 = 80.$$

By this method also we can see at once whether the contact is perfect or offers resistance; for if R = L there is no resistance; whereas if R > L the contact is not perfect.

In practice this method has given me highly satisfactory results.

F. CARDARELLI, in *l'Elettricista*.

ANSWER TO QUERY.

Theory of Wheatstone's Bridge.

10. In reference to some questions on the Wheatstone Bridge in the issue of June 8th, the following, according to my notes, is Mr. FitzGerald's demonstration, and is one which he gives to his class:—

Distribution of tensions may always be represented by triangles. Therefore, if we represent the tensions in the circuit of the

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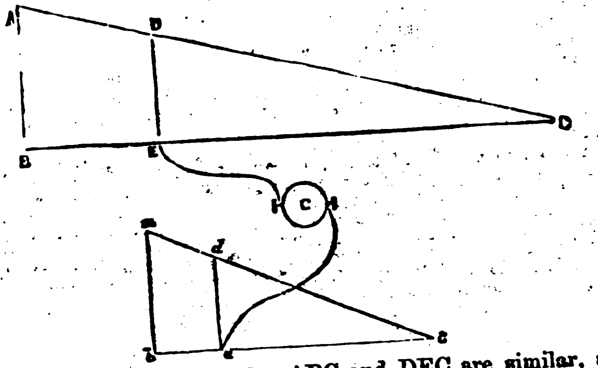
Wheatstone bridge by the triangles ABC *abc*, we have AB = *ab* = tension at B, and, since no current passes through G,

Fig. 1.



DE = *de*. Now the triangles ABC and DEC are similar, and *abc* and *dec* are also similar, then AB : DE :: BE + EC : EC, and *ab* : *de* :: *de* + *ec* : *ec*, and $\frac{AB}{DE} = \frac{BE + EC}{EC} = \frac{BE}{EC} + 1$, and $\frac{ab}{de} = \frac{be + ec}{ec} = \frac{be}{ec} + 1$.

$$\therefore \frac{AB}{DE} = \begin{cases} \frac{BE}{EC} + 1 \\ \frac{be}{ec} + 1 \end{cases}$$ and, subtracting equals from equals, the remainders will be equal.

$$\therefore \frac{AB}{DE} = \begin{cases} \frac{BE}{EC} \\ \frac{be}{ec} \end{cases} \quad \therefore \frac{BE}{EC} = \frac{be}{de} \quad \therefore DE : DE :: be : de.$$

Q. E. D.—Alfred C. M. Weaver.

CORRESPONDENCE.

"AN OLD STORY."

TO THE EDITOR OF THE ELECTRICIAN.

Sir: The "Old Story" which appeared in your last issue has no special interest for electricians, but to acousticians it must be particularly edifying, not to say vexing. The resuscitated account of a trumpet for signalling at sea unavoidably reminds us of Professor Tyndal's latest; and we wonder that those kind friends who were so anxious to minimise Professor Bell's discovery by reproducing Reiss's early attempts and failures in telephony have not been beforehand with Mr. Wilson, and proved—with much more show of reason—that Professor Tyndal copied his fog horn and siren from Captain J. N. Taylor's signal trumpet of four-and-thirty years back.—Yours, &c, Anchor.

July 15, 1878.

LITERATURE.

The Speaking Telephone, Talking Phonograph, and other Novelties. By George B. Prescott. New York: D. Appleton and Co.

There is no one branch of science or art in which we can do more than hold our own against our American cousins. The statement may seem a rash one, but we believe facts will fully bear it out. The books recently issued by the American press are admitted to be equal if not superior to similar works in England, both as regards quality of matter and the mere typographical production. We cannot point to a better astronomical work than Newcomb's; we cannot show a better mathematical periodical than that just issued under the auspices of the Johns Hopkins University; we have no paper superior to the *Scientific American* as regards illustration; and, coming to our own particular sphere, where can we point to a better book than "Prescott's Telegraphy?" In the States every workman reads; in England, as a rule, no workman reads. We refer to technical journals, not to political papers. The book whose title is given above can scarcely be said to be original, as it contains several long extracts and even papers that have been published elsewhere; still, it will be found extremely valuable, inasmuch as it gathers into one work a *résumé* of almost all that has been said or written on the subject on which it professes to treat. The book is handy in size, although it contains over 400 pages, is well printed, and illustrated with more than 200 excellent cuts. It contains a good deal of information *apropos* of Edison's discoveries in the direction of the microphone, which is exceedingly instructive. We do not intend to criticise in the ordinary way just now, but to give our readers a fair idea of what the book contains. Whether the statements are always correct remains for future consideration. In the historical introduction Mr. Prescott speaks of Lesage as being the first to establish a telegraph, using frictional electricity. Coxe of Philadelphia invented the chemical telegraph. In 1820 came Oersted's great discovery, that a current would deflect the magnetic needle, giving an impetus to research. Sturgeon made an electro-magnet in 1825, and in 1830 the late Professor Henry introduced the compound magnet. The same year he erected a telegraph of over a mile-and-a-half in length, which was worked by sound. Faraday, Gauss, Weber, hurled discovery after discovery to the world from their laboratories, and gradually we have by the labours of Cooke, Morse, Page, Thomson, &c., built up the present system of telegraphy.

We cannot help saying that we miss many names from the roll as given by Prescott; but, as in a good many other cases, our education regarding the pioneers in electrical discoveries, according to the idea of American friends, is sadly deficient and misleading.

The first portion of the book proper describes the speaking telephone; and here we have constant reference to the work of Reiss, Gray, Bell, Dolbear, Phelps, Edison, etc. It is of some importance that the work of the latter should be well understood in England, as Mr. Edison claims that he has forestalled the wonderful discoveries of Prof. D. E. Hughes; we, therefore, call attention to the following abstracts and extracts:—"Mr. Thomas A. Edison, of Menlo Park, New Jersey, has invented a telephone, which, like that of Gray, is based on the principle of varying the strength of a battery current in unison with the rise and fall of vocal utterance. The problem of practically varying the resistance controlled by the diaphragm, so as to accomplish this result, was by no means an easy one. By constant experimenting, however, Mr. Edison at length made the discovery that, when properly prepared, carbon possessed the remarkable property of changing its resistance with pressure, and that the ratios of these changes, moreover, corresponded exactly with the pressure." The device to show this consists of a carbon disc, two or three cells of battery, and a galvanometer. The carbon is placed between two metallic plates which are joined to the galvanometer and battery in one circuit through which the battery current is made to pass. When a given weight is placed upon the upper plate the carbon is subjected to a definite amount of pressure, and the current is shown by the galvanometer deflection. On increasing or decreasing the weight, differences of deflection are observed, and Mr. Edison from this devised his carbon telephone. In this telephone a carbon disc is placed between two platinum plates, these plates being connected *in the battery circuit*. Directly over one of the platinum plates is a piece of ivory, between which and the diaphragm is a piece of rubber, which is intended to dampen the movement of the disk* . . . In the latest form of transmitter which Mr. Edison has produced, *the vibrating diaphragm is done away with altogether*, it having been found that much better results are obtained when a rigid plate of metal is substituted in its place. . . In the new arrangement the articulation is so clear and exceedingly well rendered that a *whisper* even may readily be transmitted and understood. . . . The best substance so far discovered for these disks is lamp-black, such as is produced by the burning of any of the lighter hydrocarbons. Mr. Edison has found, however, that plumbago, hyperoxide of lead, iodide of copper, *powdered gas retort carbon*, *finely divided metals*, *black oxide of manganese*, amorphous phosphorus, and many sulphides may be used; indeed, tufts of fibre, coated with various metals by chemical means, and pressed into buttons, have also been employed, but they are all less sensitive than lamp-black, and have consequently been abandoned for the latter substance."

We must again specially call attention to the above paragraph, and to those words we have italicised, as their importance is very great.

Mr. Prescott says that the telephone has been extensively introduced in America on many of the short lines, and bids fair to become of almost universal application, its extreme simplicity and reliability of operation rendering it one of the most convenient of the many electrical appliances in use. Chapter II. is a reproduction of Professor Graham Bell's paper before the Society of Telegraph Engineers last October. Then comes a chapter on "The Telephone Abroad," which is interesting to read, as is the next on "The History of the Production of Galvanic Music." Next, several papers of Gray, originally read before the American Electrical Society are given, and, in fact, the whole history of the speaking telephone is collected here, but even yet we cannot say we are quite clear as to whom we must give the honour of invention. The consideration of the telephone occupies nearly 300 pages, the remainder being filled with a description of the phonograph, duplex, and quadruplex telegraphy, electric call bells, and electric lighting. Of these, we can only say the chapters are well worth reading, and are amply illustrated. Space forbids more.

THE EASTERN TELEGRAPH COMPANY (LIMITED).

Report of the proceedings at the Twelfth Ordinary General Meeting of the Shareholders, held at the City Terminus Hotel, Cannon-street, on Thursday, 11th July, 1878, John Pender, Esq., M.P., Chairman, presiding.

The Secretary, Mr. Draper, read the Notice convening the Meeting, and the Minutes of the last General Meeting were read and confirmed.

The Chairman: Gentlemen, before moving the adoption of the report, I will make, as I have usually done, a few remarks upon the accounts of the Company which you have in your hands. The gross revenue for the half-year ended the 31st March, 1878, amounts to 233,114*l.* 15*s.* 11*d.* against the corresponding period in 1877 of 224,634*l.* 16*s.* 7*d.*, showing an increase of 13,479*l.* 19*s.* 4*d.* The ordinary expenses of the Company amount, during the half year, to 58,101*l.* 14*s.* 3*d.* against March, 1877, 52,951*l.* 17*s.* 10*d.*, or an increase of 5,149*l.* 16*s.* 5*d.* The chief reason of this increase is attributable to our having to remove and lay afresh the land lines at Malta, entailing a cost of about 3,000*l.* (out of the increase of 5,000*l*). To do this we had to open trenches and lay in fourteen miles of cable from the office to St. George's Bay. There has also been an increase for maintenance charges at Aden, Marseilles and Alexandria. Salaries also show an increase of 1,830*l.*, compared with last year, principally caused, as has already been explained at the last General Meeting, by the adoption of the duplex system of working, and two new stations, namely,

* The words of the book are not given exactly as illustrative cuts are given, which we have not thought it worth while to reproduce, as any reader will easily understand the difference of this from the ordinary telephone.

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Caminha and Smyrna, having been opened. The comparative statement of increase and decrease in expenses is as follows:—General expenses in London (shown in abstract A), increase 351*l*. With the exception of salaries and office expenses, which show an increase of 184*l*. and 190*l*. respectively, the other items are about the same as last year. This extra expense has been occasioned by the increase of the capital and general business of the Company. We have likewise now to pay quarterly dividends on preference shares, in addition to the ordinary; also four half yearly coupons on the 5 and 6 per cent. Debentures. Our negotiations with the Admiralty, also the Foreign Office, and in respect of the Cape cable scheme, have also entailed extra expense, in the way of telegrams, postages, messengers, extra labour, &c. The general expenses in London compare as follows:—Six months to March, 1878:—Salaries and wages, 3,424*l*, 19s. 10d.; office expenses, 841*l*. 14s. 2d.; rent and taxes, 605*l*. 19s. 5d.; stationery and printing, 342*l*. 12s. 3d.; advertising, 66*l*. 3s. 6d.; law charges, 311*l*. 2s. 11d.; repairs and renewals of furniture, &c., 89*l*. 0s. 9d.; agency, 359*l*. 15s. 9d. Six months to March, 1877: Salaries and wages, 3,240*l*. 13s. 0d.; increase, 184*l*. 6s. 10d.; office expenses, £651 14s. 2d.; increase, 190*l*.; rent and taxes, 604*l*. 2s. 11d.; increase, 1*l*. 16s. 6d.; stationery and printing, 404*l*. 16*s*. 7*d*.; decrease, 66*l*. 4*s*. 4*d*.; advertising, 39*l*. 6*s*. 0d.; increase, 26*l*. 17*s*. 6*d*.; law charges, 264*l*. 12*s*. 5*d*., increase 46*l*. 10*s*. 6*d*.; repairs and renewals of furniture &c., 119*l*. 3*s*. 5d., decrease 30*l*. 2*s*. 8*d*.; agency 366*l*. 8*s*. 4*d*., decrease 6*l*. 12*s*. 7*d*.; working expenses at stations (Abstract B) increase 5,275*l*. The chief cause of this increase has already been explained. Stationery and printing shows an increase of 880*l*., twelve months' supplies have been sent to our stations, and, in addition, a quantity was also shipped in anticipation of the opening of new stations for the Government, which, if used by it, will be charged. Advertising shows an increase of 110*l*. We have been advertising in the French and Indian papers. The other increases, as you will see, are of very small amount. On the other hand, travelling expenses show a decrease of 283*l*.; rent a decrease of 548*l*., and furniture 719*l*. Six months to March, 1878; salaries and wages 25,792*l*.; travelling expenses, 1,324*l*.; rent, fuel and light 3,965*l*.; maintenance and renewal of land lines 6,794*l*.; repairs, &c. of furniture, 1,128*l*,; stationery and printing, 2,735*l*.; postages and porterages, 304*l*.; petty charges, 702*l*.; advertising, 180*l*.; medical attendance, 456*l*.; repairs, &c. to stations, 312*l*.; clearing house expenses, 322*l*.; freight, 65*l*.; messengers' uniforms 145*l*.; law charges, 46*l*.; expenses on cable stores, 30*l*. Six months to March, 1877:—Salaries and wages, 23,863*l*., increase, 1,929*l*.; travelling expenses, 1,607*l*., decrease, 283*l*.; rent, fuel, and light, 4,513*l*., decrease, 548*l*.; maintenance and renewal of land lines, 2,901*l*., increase, 3,893*l*.; repairs, &c., of furniture, 1,847*l*., decrease, 719*l*.; stationery and printing, 1,845*l*., increase, 880*l*.; postages and porterages, 290*l*., increase, 14*l*.; petty charges, 666*l*., increase, 36*l*.; advertising, 70*l*., increase, 110*l*.; medical attendance, 431*l*., increase, 25*l*.; repairs, &c., to stations, 293*l*., increase, 19*l*.; clearing house expenses, 319*l*., increase, 3*l*.; freight, 53*l*., increase, 12*l*.; messengers' uniforms, 82*l*., increase, 63*l*.; law charges, *nil*, increase, 46*l*.; expenses on cable stores, *nil*, increase, 30*l*.; use of patents, increase, 309*l*. We have now the duplex system in work up to Bombay. Foreign agency, increase, 254*l*. We have opened agencies in India and Australia, and new agents have been appointed there. Electrician's retaining fee, decrease, 80*l*.; extraordinary expenses, 26,179*l*., against, in 1877, 24,331*l*., increase 1,848*l*. In the six months to March, 1877, the steamship *Chiltern* was engaged in repairs and alterations to the Lisbon and Vigo cables, which cost 21,736*l*. The value of the cable used was 9,622*l*., and the balance, 12,104*l*., was absorbed by ship's expenses. There was also an item of expense of issue of preference shares, 2,595*l*., which does not occur this half-year. In the current half-year to March, 1878, the amount charged to extraordinary expenses I have just mentioned is 26,179*l*., and of this amount 1,556*l*. is for cable used in repairs. On the 13th November, 1877, the *Chiltern* sailed from London to repair a fault to the Lisbon cable off the Burlings, in the vicinity of Lisbon, which was completed on the 19th December. She then proceeded to attempt the recovery of our Direct Lisbon Cable, which was broken in deep water, owing to the mountainous nature of the ground. In this attempt she was almost successful; but the winter gales setting in, any further attemps were suspended, and the ship was ordered home. We believe we have 200 miles of cable at the bottom of the sea between Vigo and Lisbon, which can yet be made to constitute a duplicate line between those points, and but for the occurrence of new work in the Mediterranean, the restoration of this cable would have been attempted this summer; but, as it is not essential to our traffic, we at once fitted out the Company's s.s. *Chiltern* for laying, in concert with the s.s. *John Pender*, the cables connecting Chio-Tenedos, Syra-Crete, largely on account of Her Majesty's Government. In the interval, while these preparations were being made, the Directors, in one of the steamers, visited all the stations as far as Egypt, and, we believe, materially strengthened the good understanding which had always existed with all the governments on whose shores our cables are landed. Since then we have, in agreement with the Government of Turkey, laid a cable from Constantinople to Tenedos, a distance of 180 miles; and we are prepared to lay it from thence to Salonica, 189 miles, but, owing to the frequent changes of ministries in Turkey, this has not yet been satisfactorily arranged, although we have reason to believe it will be now finally adjusted within three or four days.

Now, gentlemen, I have given you these details so that I may afford you a better knowledge of the accounts which are in your hands. As I have mentioned, our revenue for the half-year shows an increase of 13,479*l*. over the corresponding period of 1877. This increase is much smaller than the increase in the first half of the financial year, with which we are now dealing, over the corresponding period of 1876; but the Shareholders must remember that during the half-year ending September, 1877, for a period of four-and-a-half months the whole of the traffic with India passed over this Company's cable. That arose from the Indo-European line being interrupted during the war. This circumstance is the cause of the large decreases of traffic we have had to publish during the months of May and June. The Indo-European line, which broke down in May, 1877, was restored in August, and the joint-purse agreement with the Indo-European Company came into operation on the 1st September last. I referred to that joint-purse arrangement at the last half-yearly meeting, and I am glad to say it has been working not only satisfactorily, but it gives a much greater security to the Company in the event of any breakage occurring to our own cable. We have been so satisfied with that arrangement that we have felt that if we could induce Her Majesty's Government to join the combination so as to bring into it the Persian Gulf cable it would give us virtually all we could ask for in maintaining an efficient, steady, and reliable communication. This joint-purse agreement to which it is now proposed the Telegraph Department of the Indian Government shall become a party, is based on the assumption that 60 per cent. of the Indian traffic would pass by this Company's route, and 40 per cent. by the other route. That 80 per cent. of the Trans-Indian traffic, that is traffic exchanged with China, Java, and Australia, would go by our line, and 20 per cent. by the Indo-European line. The public being the sole judges of the route by which their messages shall be sent perhaps favour this Company with a somewhat larger proportion of the traffic than was anticipated, but we do not object to this. The receipts from the two classes of traffic, Indian and Trans-Indian, are divided according to the proportions given in the agreement. The division of the gross revenue may be roundly stated as two-thirds to the Eastern and one-third to the Indo-European and the Persian Gulf. This is when all routes are working. If we are interrupted for twelve months we get more than half the traffic receipts by the other line, namely, 51·51 per cent. If the other route be interrupted we get 69·44 per cent. instead of 65·64 per cent. The agreement is one for mutual protection. We part with something now in order to ensure a continuous revenue, and make our system a better security for investors. The present agreement has worked without friction, and the directors recommend the new one to the Shareholders for their approval. The agreement will shortly be read by the Solicitor. Now, I have been particular in putting all these facts and figures on paper so that you may perfectly understand them, and that they may also be understood by the Shareholders who are not present here, and who of course are largely and anxiously interested in everything that passes at these public meetings. I have, therefore, been more than usually careful that the facts should go before them fully. Now, gentlemen, before moving the adoption of the Report, I would just wish to make a few more remarks. I may mention that our system in the Mediterranean and the Levant is working very satisfactorily indeed. We have with a very small exception the whole of the cable system in these seas. We have been in communication with the different governments, and we wished them to understand, as I think they now do understand fully, that, although the head-quarters of this Company are in London, we are virtually an internatianal Company, and that our object is to bring about an efficient and satisfactory system of telegraphic communication betwixt the different important points in the world. I think we have also satisfied those countries, who have had some interest in cables in those seas, that through our system and the general management exercised, having our ships on the stations, and our cables ready at all times to avail ourselves of any opportunity either for extending or repairing our system, their interests are better in our hands than in any other hands, as we can do it not only cheaper, but quicker and more efficiently than they can. Therefore, we are extending our friendly relations with these countries, and are gradually gaining their confidence. We are now negotiating for further extensions. I hope ere long to be able to announce that a cable will be connected from Aden to Zanzibar, Mauritius and the Cape. We have progressed so far, but still we are not yet in a position to say that the negotiations are completed. When they are completed the full details will be laid before the Shareholders. We are hopeful, and we believe that they will approve of the arrangements that we make with the colonies for the laying of the cable to Australia. The Australian colonies are so well satisfied with the cable they have got that we are now negotiating to lay an additional cable for security. Our present cable is quite equal to doing the work required, but having once tasted the sweets of telegraphy, the breakages that have occurred have so upset their calculations, that they are determined to have a duplicate, and they have agreed to pay something like 32,000*l*. per year for a good number of years [applause]. I am rather going a little too far. It is to the *Eastern Extension Company*, but in mentioning that I need hardly say that it will bring a large increase of traffic over our line [applause]. Now, gentlemen, there is another thing I will mention, and then I shall have concluded my remarks. Your Directors thought that looking to the peculiarity of the state of affairs in Europe, they would never know from day to day whether an additional cable might be wanted, and we thought that not only as patriotic citizens, but having due regard to the interests of our Shareholders, we ought to be prepared to do that work, if it were required to be done. We, therefore, had our ships stationed at Malta, supplied with cable, and I may say that the Construction Company, in the most liberal way put on board our ships an amount of cable, taking the chance of its being used or not, so that in the event of anything occurring that required a cable immediately being laid, it would be at once taken advantage of [applause]. I may tell you that at one period of those important matters, when the war was going on, our ships were not in immediate connection with England; but within a short space of time, I think eight days, we had our cable laid to Besika Bay, and in immediate connection with our fleet [applause]. Therefore, I hold we have done no harm to the Company in looking beforehand, and I think we have done a very great and important service to the country [applause]. There is another thing which occurred the other day, in which many are interested, and with regard to which many will hold different opinions; but I think there is one opinion in which we will all concur, viz., that if we connect Cyprus with our system, we will be doing a happy thing for the country and a good thing for ourselves. There is a question in the Report which I am bound to mention —I refer to the eighth paragraph of the report in regardto the re-election of Baron D'Erlanger at the last meeting. I think I cannot do better than read a document which your solicitor has put into my hands, because I think questions of that kind should be treated temperately, that each party should understand exactly the position they occupy legally, and that we should lose sight of everything but the best interests of the Company, which we as directors represent, and which you as shareholders are a party to. I may mention that Mr. Newton has thought it right to address a letter to *The Times* on the subject. Mr. Newton, of course, has a perfect right to do exactly what he thinks best. If he thinks that through the public press he can better strengthen his position, I have no fault to find with Mr. Newton. All I wish to say is that it is well the shareholders as a body should understand exactly the proceedings of last meeting, and thus fully judge for themselves as to whether Mr. Newton is entitled to support, or whether the directors are entitled to the support which they claim from

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the shareholders. Our solicitor writes:—"Mr. Newton says that the "report afforded an example of the indifference of the directors to the wishes "of the proprietors. That is not the fact. The directors, as well as Mr. "Newton, are bound by the Articles of Association, and have no alternative "but to treat Baron D'Erlanger as still a director." The solicitor was no doubt to blame in not remembering Article 81 of the Articles of Association. And I confess now that I as chairman ought to have known that Mr. Newton was irregular in that transaction [applause]. I am quite prepared for blame, but I was not aware at the moment that Mr. Newton was a Preference Shareholder, and not an Ordinary Shareholder, and I was anxious as far as possible to meet the wishes of Mr. Newton, and to have an expression of opinion fairly from the body of the Shareholders. For the moment it did not occur to the solicitor that the thing was irregular, but had it been shown to be so the whole thing would have dropped down. Now, we come to deal with it, each party knowing exactly what the position is. "The solicitor was no doubt to blame in not remembering Article 81 of the "Articles of Association, and he much regrets the defect of memory, but it "must be borne in mind that no notice was given of Mr. Newton's amend- "ment, and that it was sprung on the meeting unexpectedly so that the "solicitor was unprepared. If, however, he had called the attention of the "meeting to the Article it would probably have resulted in the amendment "not being carried. Mr. Newton speaks of the Articles of Association as "unjust, but the Article in question is very necessary in the interests of "Shareholders, and is in the common form. If a few Shareholders at a "meeting could prevent the election of Directors and thereby leave the "Company without authorised managers the result would be far worse than "treating a Director as re-elected whose re-election by a majority of the "Shareholders present had not in fact taken place, and in whose place no "one else had been appointed. Mr. Newton as a holder of Preference "shares was not entitled to vote at the meeting, and it is doubtful whether "he was entitled to move a resolution upon which he could not vote. The "number of Shareholders present was 52 out of 8,000, and the number of "Ordinary shares represented in the room, except those held by the "Directors, was only 3,619, out of a total of 369,700, being less than one "per cent. of the Ordinary capital. The largest Shareholders in the room "voted against Mr. Newton's amendment. All the Shareholders had "received notice of the proposal to re-elect Baron D'Erlanger, and not "one of them had made any objection until Mr. Newton rose at the "meeting."

A SHAREHOLDER: I beg to say——[interruption and cries of "Order."]

The CHAIRMAN: When I have finished I shall be glad to hear any gentleman. "Baron D'Erlanger, the person chiefly affected, was not present, being, as I understand, absent in Germany, on account of the death of his father. Immediately after the result of the meeting was made known to Baron D'Erlanger, he wrote to the Chairman, placing his resignation in the hands of the Board, but the Directors unanimously declined to accept it." Now, gentlemen, that is the position as between Mr. Newton and the Board, and I think it is necessary to make these statements clearly and distinctly, so that the Shareholders at a distance may understand exactly the position of affairs. I would only add this, gentlemen, that if your Directors are to manage the business of this Company, they must have an important interest in using the best tools in their power to make the business a successful business. Therefore, the Directors, in not accepting Baron D'Erlanger's resignation,—because he really was a Director,—felt that the interests of the Company had been largely benefited by him as a Director in France in one particular point [applause]. He is largely interested in the Company, and I think the Directors were only doing their duty to him and to the Shareholders of the Company—[a voice, "No"]—by not accepting his resignation. Now, gentlemen, with these remarks, I beg to move:—"That the report and accounts of the Directors, submitted to this Meeting, be and are hereby received and adopted; that a dividend on the preference shares of the Company to the 30th June, 1878, at the rate of 6 per cent. per annum be paid, less income-tax; and that in accordance with the Directors' recommendation a dividend be and is now declared of 2s. 6d. per share, free of income-tax, on all the ordinary shares of the Company, making with previous payments by way of dividends on account, a dividend of 5 per cent. on those shares for the year ending 31st March, 1878."

LORD WILLIAM MONTAGU HAY (Vice-Chairman): I beg to second that resolution.

The CHAIRMAN: Now, gentlemen, before I put the resolution to the Meeting, if any gentleman wishes to make any remarks upon the accounts or upon any of the statements that I have made, I shall be very glad to hear it.

Mr. ROBERTS: At the meeting before last I said Baron D'Erlanger was not a proper person to be on the Board.

The CHAIRMAN: Gentlemen, if there is no other person who wishes to speak, I shall put the resolution.

GENERAL HAMLEY: What I wish to ask is this. It was stated at the last meeting—at least we were led to understand—that Baron D'Erlanger retired by rotation from being a director [hear, hear]. He was, therefore, not in the position of a director, and there was no possibility of putting him upon it, because he had already ceased to be a Director. Then it was necessary he should be re-elected in some way or another. I do not remember any re-election at all. I am saying nothing about the amendment. You may be right about the amendment being irregular, but if the amendment was irregular will he be required to be re-elected? He became but a member of the Company, he had ceased to be a director, and you re-instated him in his position.

The CHAIRMAN: Would you like the solicitor, to save time in talking, to reply to that and put us right legally?

General HAMLEY: I have one other remark to make with reference to what you have said [hear, hear]. You spoke this moment of the paucity of the meeting, and of their insufficiency for putting aside a director. Now, you will remember that we not only put aside a director, but we also elected one. Was the meeting sufficient to elect Colonel Glover? [hear, hear.] I should like to have that question answered, as to whether Baron D'Erlanger was ever re-elected legally?

The CHAIRMAN: I think it is better the solicitor should reply.

Mr. BURT (the Solicitor): The Report states that the amendment having been passed, the Directors were afterwards advised that legally the amendment was inoperative, and that Baron D'Erlanger continued to be a Director of the Company. The Article 81 is as follows:—"Whenever the ordinary meeting in any year fails to elect a Director instead of the retiring Director, the Director shall be considered to have been re-elected." I am very sorry, as the Chairman has mentioned, that when this matter was before the last meeting I did not remember this Article. Gentlemen, you will, perhaps, consider it excusable, to some extent, when I tell you there are 188 Articles, and I do not think you will expect me to remember the whole of them at a moment's notice. If I had called attention to it, and to the fact that Mr. Newton who moved it was a holder of five Preference Shares, and had no right to vote or move a resolution, I have no doubt the Chairman would have, properly and legally, held that the amendment was out of order, and could not be put. But the answer I have to give to General Hamley is, that the Article 81 expressly states that unless a director is elected in the place of the retiring director, that director is considered re-elected. If twenty gentlemen came to a meeting determined to put a Company in a fix, they would have only to prevent the re-election of any Director, and the Company would be without managers at all. It is therefore provided by this article that such a course could not be taken, and in justification of that I can say that by the Companies' Act, 1862, the articles set forth as model articles have a nearly similar provision, and not only so but every railway and dock company is subject to a similar regulation to the same effect. I hope, therefore, it will not be thought that these articles have been framed with any desire to give any special advantages to directors. I regret very much that Mr. Newton should have criticised these articles as being unjust. I always thought these articles were fair and legitimate, protecting the best interests of the shareholders, as I believe they do [applause]. If it is needful any one can see the counsel's opinion which has been taken on the subject. (The solicitor then read the opinion.) The statement of the number of shareholders present being so small was simply to point out that there were only 52 present representing one per cent. of the whole number, and that the 99 per cent. knew nothing of what was being done; on the contrary, they would expect from the report giving notice of the re-election of Baron D'Erlanger, that it would be carried as a matter of course.

Mr. ROBARTS: I will now move that the first time Baron D'Erlanger is about to be re-elected we do not re-elect him.

The CHAIRMAN: Now, in reply to the last speaker, let me say this word; and it is that everything is brought forward in proper form by your board; and in public meetings we shall only be too glad to give every possible facility to have opinions ventilated.

The CHAIRMAN then put the resolution for the adoption of the Report and Accounts to the meeting, when it was carried unanimously, amidst applause.

The CHAIRMAN: Now, gentlemen, the next business is for the Solicitor to read the heads of the Agreement with the Indo-European Telegraph Department of the Indian Government, and the Indo-European Telegraph Company.

The SOLICITOR then read the Agreement.

The CHAIRMAN: Gentlemen, you have heard the Agreement read. I shall now move—

"That the heads of Agreement, dated 28th May, 1878, between the Indo-European Telegraph Department of Her Majesty's Indian Government, the Eastern Telegraph Company, Limited, and the Indo-European Telegraph Company, Limited, as to the Indian and Trans-Indian Traffic Receipts, submitted to this meeting, be and are hereby approved and confirmed, and that the Directors be and are hereby authorised to do all things needful and expedient for carrying the same into effect, either as the same now stand, or with any modifications as to the details thereof, which the Directors approve."

Sir JAMES ANDERSON (Managing Director): I shall have pleasure in seconding that.

A SHAREHOLDER: Will this Agreement be circulated among the Shareholders?

The CHAIRMAN: I may say that this Agreement will be lying at our office, and open to the inspection of any Shareholder who chooses to go there. I may further mention, and perhaps there are Shareholders here who recollect, that four or five years ago I stated that it was the policy of the Board, if it could be carried out consistently with the interests of this Company, to bring about such a combination with the Indo-European and Her Majesty's Government, as would give us what we have now completed to-day. We have been successful in carrying that out, and I believe it is for the interest of Shareholders. It makes the property a much more secure and stable one; and I believe it will in many respects lead to economies.

The resolution was then put, and agreed to *nem. con.*

The CHAIRMAN: Now, gentlemen, that finishes the business of the meeting, and I have to thank you for your attendance here to-day.

Mr. WILLIAM FORD: Mr. Chairman and gentlemen, before we part I desire to say a few words. I regret exceedingly that the time of this meeting, which I think had better have been given to the consideration of the important agreement that has been read, and to the policy of the Board, should have been diverted from that and other important subjects, by reference to one paragraph in the report, on a subject which, I may say, the law has settled for us, and discussion is wholly unavailing. At no period of the history of this Company, as it appears to me, have the Directors rendered to this Company more important services than they have done during the last half year. I, myself, have had occasion to visit the offices of this Company very frequently, and I have found every member of the staff engaged most laboriously with these important negotiations and operations [cries of "Time"). Gentlemen, on the subject of time, I do not think that one moment is useless which leads to a just appreciation of the services of your Directors [applause]. I, therefore, beg to propose a vote of thanks to the Directors [applause].

Colonel HUME: I beg to second that.

The Solicitor put the resolution to the Meeting when it was cordially agreed to.

The CHAIRMAN: Gentlemen, on behalf of myself and my co-directors, I return you our best thanks. During the very trying time that has just been referred to, we have, I think, carefully looked after your interests. I may, I think, draw attention to the fact, that during that time when other interests were showing very great variations, your property has maintained its position in the face of everything. Gentlemen, I have to thank you.

The proceedings then terminated.

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RECENT PATENTS.

4222. Magnetic Apparatus for Ringing Bells, &c., *G. Zanni.—Dated 13th November*, 1877. *6d.*

This relates to improvements on patent No. 2721, dated 13th October, 1877, and consists of employing an ordinary horseshoe magnet in place of the circular magnet there described. A revolving coil is placed within the arms of the magnet close to the open end, a portion of the magnet being cut away on each side so that the coil partly fits within such curved spaces.

4231. Compasses, *by W. H Hassler. Dated Nov.* 15, 1877. *6d.*

The object of this invention is principally to remedy the inconvenience of not immediately recognising the north and south pole. This is effected by fixing on the magnetic needle, or on the card carried by it, a small light figure of some living thing, such for example as a bird in the act of flying, a quadruped in the act of running, a man in the act of rowing, and the like. The bird or quadruped or living thing is by preference fixed on the magnetic needle or card in such a position that its head points to the north.

4321. Duplex Telegraphy, *J. X. E. Sieur. Dated November* 19, 1877.

This invention relates to a system of arranging and working electrical sending and receiving instruments in connection with a line wire, such that the one wire is made to serve for the transmission of two sets of messages or signals sent by two separate operators working at the same time, and, by combining this system with arrangements for duplex telegraphing, the one line wire is rendered capable of quadruplex working, that is to say, of conveying two sets of signals sent simultaneously from each terminal station. A cam, eccentric, or its equivalent, connected to earth, is caused by clockwork or other suitable motor to revolve rapidly between two spring contact levers, the one of which is connected to the positive and the other to the negative pole of a battery. These levers are thus caused to oscillate rapidly to and from their respective contacts, the one of which is connected to a contact for one operating key or sending instrument, and the other to a contact for another such key or sending instrument. Both these keys or senders are connected to the one line wire, which is thus made to receive only positive currents from the one key or sender, and only negative currents from the other, such currents being in each case intermittent, but succeeding each other rapidly. The line wire leads to a coil having a pair of polarised armatures, or to a pair of polarised relays, the one of which is actuated by positive currents and the other by negative currents, each operating a local battery in connection with a receiving instrument. Thus the one receiving instrument being affected only by positive currents imparts the signals transmitted from one of the senders, and the other imparts those transmitted from the other sender. As the positive and negative currents alternate, the one set of signals does not interfere with the other set, and, as the succession of impulses of either sign is rapid, the effect on each receiver does not practically differ from that produced by a continued current of the sign for which the receiver is adapted.

4341. Applying Wires for Conveying Electricity, *A. G. Bell.—Dated 20th November*, 1877. *4d.*

This relates to improvements on patent No. 4765, dated 9th December, 1876, and consists of employing two conductors or wires with the telephone, one being the return wire. By this arrangement all disturbances from neighbouring wires are prevented, if care be taken that the two conductors are within a much shorter distance of each other than the distance to the wire from which the disturbance is expected.

4402. Telephone, *J. A. Ewing and F. Jenkin.—Dated 22nd November*, 1877. *(Not proceeded with.)* *2d.*

The transmitting and receiving instruments are similar in construction; they consist of a wire or wires capable of vibrating to definite musical notes, and so stretched with or without resonators in a magnetic field as to vibrate when in action across the lines of magnetic force. The telegraphic circuit consists of these wires, the line and the earth.

TELEGRAPH SHARE LIST.

Amount of Issue.	Amount of Share.	Paid on Share.	Company.	Reserve as per last Report.	Dividends calculated at rate per cent. per annum. 1875. %	1875. %	1876. %	1876. %	1877. %	1877. %	When Payable.	Prices. 1875. Highest.	1875. Lowest.	1876. Highest.	1876. Lowest.	1877. Highest.	1877. Lowest.
£3,254,580	Stock	100	PAnglo-American	Deferred receiving no dividend until 6 per cent. has been paid to Preferred.		year.	5	4†	3	5	† Div. 5 % per ann. for quarter ending Dec. 31, 1876, 2 % for quarter ending Mar. 31, 4 % for quarters ending June 30 and Sept. 30, 6 % for quarter ending Dec. 31, 1877, and 4 % for quarter ending March 31, 1878.	75½	51½	68¾	53	62½	52
1,872,710	Stock	100	Do. Preferred B		—	—	10	2	6	6		Crtd	1876.	93	75	88½	79
1,872,710	Stock	100	Do. Deferred A		—	—	Nil.	6	Nil.	4		Crtd	1876.	44	29	38	25½
1,300,000	10	All	Brazilian Submarine	120,000	5	5	5	5	5	5	Quarterly.	7½	6	7½	5¾	6¾	5¾
160,000	10	All	Cuba (Limited)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60,000	10	All	Do. 10 per cent. Preference	—	—	—	—	—	—	—	—	—	—	—	—	—	—
116,379	10	9	Direct Spanish (Limited)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
58,430	10	All	Do. 10 per cent. Preference	—	—	—	—	—	—	—	—	—	—	—	—	—	—
65,000	20	All	Direct United States	Nil.	—	Nil.	Nil.	Nil.	Nil.	5	Quarterly.	13	7	11½	6¼	13½	9½
369,700	10	All	Eastern (Limited)	110,000	5	year.	5	5	5		aJany., April, July, Oct.	8	6⅛	7⅛	5	8¼	6⅜
232,000	100	All	Eastern 6 per cent. Debentures	—	—	—	—	—	—	—	—	—	—	—	—	—	—
200,000	100	All	Do. 5 per cent. Debentures	—	—	—	—	—	—	—	—	—	—	—	—	—	—
700,000	10	All	Do. 6 per cent. Preference	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,997,500	10	All	Eastn. Exten. Australasia & China	125,404	5½	year.	5	year.	5	year.	aJany., April, July, Oct.	8¼	7	7½	5⅛	8	6⅛
320,000	100	All	Eastn. Exten. 6 p.c. Deben. (1875)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
192,680	10	All	German Un. Tl. and Tst.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,500,000	10	All	Globe Telegraph and Trust	Nil.	5	7 4-5	4½	7 5-6	3¾	7 6-7	bJany., April, July, Oct.	6¾	5⅛	5⅞	4½	5½	4¼
1,500,000	10	All	Do. 6 per cent. Preference		6	6	6	6	6	6	Jany., April, July, Oct.	10½	9¾	10½	9½	10⅜	9¼
150,000	10	All	Great Northern	85,543	5⅝	year.	6⅝	year.	6⅝	year.	5 % intrm. Jan. 1, July 1. Final Dividend April.	11½	7½	9¾	7	8	7
			Shares to Bearer, or can be Regstrd.														
—	25	All	Indo-European	—	—	—	—	—	—	—	—	—	—	—	—	—	—
120,000	10	All	Mediterranean Extension (Lmtd.)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
32,000	10	All	Do. 8 per cent. Preference	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	18	All	Reuter's (Limited)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
65,000	10	All	West India and Panama	16,000	Nil.	Nil.	Nil.	Nil.	1	1	‡ Converted from a 10 % into a 6 % 1st Preference.	4¾	1½	2½	⅝	3¾	1¼
34,563	10	All	Do. 6 per cent. Preference		7/6ac	year.	10/ac	year.	6‡	6		12	9	11	7	11	7¼
67,500	20	All	Western and Brazilian	7,793	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Half-yearly.	18½	9½	10⅜	4½	5½	4¼
$1,500,000	$1000	All	Western Union Telegraph 7 per cent. First Mortgage Bonds	—	7	7	7	7	7	7	May, November.	108	102½	109½	105	113	106
£1,030,000	200	All	Do. 6 per cent. Sterling Bonds	Redeeemable by annual drawings at par.	6	6	6	6	6	6	March 1, September 1.	93	86	98	89	101	94

a Year ends March 31st. Interim Dividend of 5 per cent. Final dividend in July.

b Year ends July 18th. Final dividend in July.

Companies.	Closing Prices 17th July.	Business Done Week Ending 17th July. Highest.	Lowest.
Anglo-American	63¾, ⅞ ex div.	63¾ cum d.	63½ cum d.
Do. B.	91½, ¾ ex div.	93¾ cum d.	92¾ cum d.
Do. A.	36¾, 7½	37	36½
Brazilian	6 15-16, 7 1-16 ex div.	7½	6 15-16
Cuba	9¾, ¼	9¾	9½
Do. Ten per Cent. Preference	16¾, ¼	—	—
Direct Spanish	1¾, 2¼	—	—
Do. Ten per Cent. Preference	9½ 10	—	—
Direct United States	14¼, ¾	14¾	14½
Eastern	7¾, ⅞ ex div.	8	7 13-16
Do. Six per Cent. Debenture	108, 110	110¼	110¼
Do. Five per Cent. do.	103½, 4½	—	—
Do. Six per Cent. Preference	11½, ¾ ex div.	12	11¾
Eastern Extension	7¾, ⅞ ex div.	7 15-16	7¾

Companies.	Closing Prices 17th July.	Business Done Week Ending 17th July. Highest.	Lowest.
Do. Six per Cent. Debentures	109, 111	—	—
German Union	8½, ¾	—	—
Globe Telegraph and Trust	5 7-16, 9 1-16	5 9-16	5½
Do. Six per Cent. Preference	11, ½	11½	11½
Great Northern	8¼, ¾	8¾	8½
Indo-European	20, 21	—	—
Mediterranean Extension	2½, ¾	3	2¼
Do. Eight per Cent. Preference	9½, ¾	9¾	9½
Reuter's	10, 11	—	—
West India and Panama	2 7-16, 9-16	2 9-16	2½
Do. Six per Cent. Preference	8½, 9	9	8¾
Western and Brazilian	4½, ¾	4¾	4½
West. Union 7 p. Cent. 1st Mortgage	117, 119	—	—
Do. Six per Cent. Sterling	102, 104	—	—

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NOTES.

School of Telegraphy.—The French Government has established a school specially devoted to the study of telegraphy.

The Eastern Extension, &c., Telegraph Company (Limited).—The coupon of the Six per Cent. Debentures due on August 1 will be paid by the Consolidated Bank on and after that day.

Eastern Telegraph Company.—The coupons of the Five Per Cent. Debenture Stock of this Company are payable on the 1st August next, at the banking house of Glynn, Mills, and Co., Lombard-street.

Capital of Cable Owners.—The capital of the companies owning the cables, as mentioned in our issue of the 20th inst., amounts to nearly 22,000,000*l.* Government capital, which has constructed about 3,000 miles of cable, is not included in this total.

Telegraphic Connection with Cyprus.—Mr. Pender, the son of J. Pender, Esq., M.P., is announced to have reached Cyprus, where he intends to make the necessary preparations for connecting the island by means of a submarine cable with the other Mediterranean stations.

The Globe Telegraph and Trust Company (Limited).—The accounts show a balance available for dividend which will enable the directors to recommend a final dividend of 3s. per share on the preference shares, making 6 per cent. for the year ending July 18, 1878, and of 2s. per share on the ordinary, making 4 per cent. for the year.

Duplex and Quadruplex Telegraphy in the States.—The progress of American land lines certainly compares favourably with that of England. We can boast of one quadruplex circuit. America has fifty-nine such circuits, comprising 16,157 miles of line; while it has also fifty-two duplex circuits, containing 14,580 miles of line, giving a grand total of 30,737 miles working duplex or quadruplex.

The Microphone.—The amount of battery power neccessary to operate the microphone is very small, any form answering the purpose. Indeed, very satisfactory results have been obtained by a battery composed of a copper cartridge case, one-quarter of an inch diameter, and half an inch long, filled with salt water, and a piece of zinc wire passing through the cork which closed the open end. In another case a voltaic pile was used, consisting of a copper cent and a piece of sheet zinc of equal size, separated by blotting paper wet with acidulated water.—*Jour. Frank. Inst.*

New Telephone Diaphragm.—M. Louis Olivier has lately devised a form of telephone which differs from the ordinary Bell apparatus chiefly in the shape of its diaphragm. This, instead of being a merely circular plate, is concave of unequal thickness and elliptical in shape. Its general plane is also inclined to the axis of the instrument. It is attached by the edges, and a thread of silk is fastened to it at its thickest part. The inventor states that the idea is to imitate the construction of the drum of the human ear more perfectly, and that the *timbre* of the voice is preserved by the improved diaphragm with great accuracy.

New Dielectric Constant. By M. Neyreneuf.—On contining the comparison of different insolating substances employed as the dielectric plates of a condenser, the author has established that for glasses of the same nature that the ratio $\frac{e}{n}$ of the thickness to the number of sparks corresponding to a given quantity of electricity was constant. He has almost determined the value of this ratio for the varieties of glass met with in commerce. For substances much more insolating—such as ebonite, caoutchouc, and paraffin—the above ratio, which may be called the condensing constant, goes on increasing in a marked manner with the thickness. Consequently, only results obtained with plates differing respectively little in thickness are comparable.—*Compt. Rend.*

The Microphone.—After describing Professor Hughes's microphone, the current number of *Naturforscher* remarks that it is based on essentially the same principle as a telephone arrangement lately devised by M. Lüdtge, and described to the Berlin Physical Society in April. In both, the Bell telephone is used as receiving apparatus; in both, it is the variation by means of sound vibrations of the mutual pressure of two conducting surfaces inserted in the circuit, that causes a variation of the resistance, and so of the intensity of the current. Only M. Lüdtge employs two metal plates in contact, or plates and clippings, while Professor Hughes uses prepared carbon. M. Lüdtge stated also that his apparatus was so sensitive that one easily heard, with the receiving apparatus, conversation in a neighbouring room, the slightest shaking of the table on which the instrument stood, by placing the hand on it, &c.

Depolarisation of Electrodes by Solutions. By M. Lippmann.—The depolarising power of certain salts has long been known. The first constant current battery constructed in 1829 by M. Becquerel depends on the use of copper sulphate, whilst zinc and cadmium sulphates have been utilised by MM. Du Bois-Reymond and J. Regnault for the construction of impolarisable electrodes and of constant elements. This property, however, has not been studied. The author's experiments reveal an essential condition of the phenomenon. In order that an electrode may be depolarised it must be formed of the metal which is contained in the solution. Thus, copper is the only metal which is depolarised in copper sulphate, whilst gold, silver, and platinum are polarised in this solution. On the other hand, copper is polarised in zinc and cobalt sulphates, &c. A salt depolarises only its own metal. This principle may be applied to the detection of a metal in a solution. Taking, for example, copper, if a wire of this metal be plunged in a solution under examination, and taken as the negative electrode of a feeble current, it will not be polarised if the liquid contains 1-5000th of copper sulphate. The presence of copper may thus be detected in a mixture of metallic salts. With a silver wire silver may be detected in like manner.—*Compt. Rend.*

British Post Office Telegraphs.—The account of receipts and payments by the Postmaster-General in respect of the Post Office Telegraphs for the financial year ending on March 31, has just been issued. It shows that the payments amounted to 257,743*l.*, of which sum the receipts fell short to the extent of 2,492*l.* The capital account shows that, out of a total authorised capital of 1,751,040*l.*, 1,610,005*l.* has been expended. The Comptroller and Auditor-General, in his report, explains that the sum of 226,272*l.*, claimed credit for under the head of expenditure for telegraph undertakings, includes certain amounts which have been excluded as having been otherwise adjusted, and these sums being deducted would leave the total expenditure for the year at 225,091*l.*, for which the Treasury authority has been furnished. The charge of 6,713*l.* against the telegraph capital account is admitted, in pursuance of the recommendation of the Public Accounts Committee. During the year eighteen of the officers of the late telegraph companies have commuted their pensions,

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and 18,413*l.* has been paid to them. Appended to the Auditor-General's report is an abstract account prepared in his department showing the recepts on the telegraph capital account, from its commencement to the 31st March last, as having amounted to 9,609,741*l.*, and the payments to 9,612,079*l.*, leaving a deficit of 2,338*l.* Out of the sum of 9,750,000*l.*, authorised under the Telegraph Acts of 1869, 1871, 1873, and 1876, expenditure to the amount of 9,612,079*l.* has been allowed, leaving a balance of 137,921*l.*, to which must be added the sums received for the sale of premises, old fittings, and the steamer *Monarch* 2,546*l.*, as shown in his previous reports, and the sum of 588*l.* received from the Gaeat Eastern and Cowes and Newport Railway Companies, and handed over, in pursuance of Treasury instructions, to the Postmaster-General, for the purpose of being placed to the credit of the telegraph capital account; making the total amount available for future expenditure 141,035*l.*

Lord Raleigh on the Explanation of Certain Acoustical Phenomena.—Musical sounds have their origin in the vibrations of material systems. In consequence of its connection with a source of energy, a vibrating body is subject to certain forces, whose nature and effects are to be estimated. These forces are divisible into two groups. The first group operate upon the periodic time of the vibration, *i.e.*, upon the pitch of the resulting note, and their effect may be in either direction. The second group of forces do not alter the pitch, but either encourage or discourage the vibration. In the first case only can the vibration be maintained; so that, for the explanation of any maintained vibration, it is necessary to examine the character of the second group of forces sufficiently to discover whether their effect is favourable or unfavourable. The effect of a small periodic horizontal impulse on a pendulum is in general both to alter the periodic time and the amplitude of vibration. If the impulse (supposed to be always in the same direction) acts when the pendulum passes through its lowest position, the force belongs to the second group. It leaves the periodic time unaltered, and encourages or discourages the vibration according as the direction of the pendulum's motion is the same or the opposite of that of the impulse. If, on the other hand, the impulse acts when the pendulum is at one or other of the limits of its swing, the effect is solely on the periodic time, and the vibration is neither encouraged nor discouraged. In order to encourage, *i.e.* practically in order to maintain a vibration, it is necessary that the forces should not depend solely upon the position of the vibrating body. Thus, in the case of the pendulum, if a small impulse in a given direction acts upon it every time that it passes through its lowest position, the vibration is not maintained, the advantage gained as the pendulum makes a passage in the same direction as that in which the impulse acts being exactly neutralised on the return passage, when the motion is in the opposite direction. As an example of the application of these principles, the maintenance of an electric tuning-fork was discussed. If the magnetic forces depended only upon the position of the fork, the vibration could not be maintained. It appears, therefore, that the explanations usually given do not touch the real point at all. The fact that the vibrations are maintained is a proof that the forces do not depend solely upon the position of the fork. The causes of deviation are two: the self-induction of the electric currents, and the adhesion of the mercury to the wire whose motion makes and breaks the contact. On both accounts the magnetic forces are more powerful in the later than in the earlier part of the contact, although the position of the fork is the same; and it is on this *difference* that the possibility of maintenance depends. Of course, the arrangement must be such that the retardation of force *encourages* the vibration, and the arrangement which in fact encourages the vibration would have had the opposite effect if the nature of electric currents had been such that they were more powerful during the earlier than during the later stages of a contact.

Volunteer Torpedo Corps.—A proposal for the establishment of volunteer torpedo corps, made some time ago by a retired naval officer, Lieut. F. I. Palmer, R.N., lately commanding Her Majesty's ship *Magdala* in Indian waters, has been brought into practical operation on several portions of the coast, and special torpedo brigades have been organised in connection with the rifle volunteer corps in several of the maritime towns on the East and South coasts. The adoption of this course has much to recommend it. The establishment of torpedo depôts, the members of which may take the necessary observations as to tide, depth, nature of the sea bottom, &c., and make preparations for laying submarine mines in case of emergency, will do much to place such localities in a proper state of defence. On the question of expense, the fitting out and the maintenance of a swift torpedo cutter will be a much less costly business than the erection of land batteries or the maintenance of a sea-going cruiser, or even of a hulk fitted up for marine artillery practice, as is necessary in the case of the Naval Artillery Volunteer Corps. The advantage of such a service would nowhere be so great as in the case of the great centres of our maritime trade in the neighbourhood of the Tyne, the Tees, the Wear, the Humber, and other principal rivers of the country, many of which are inadequately protected by the ordinary means of defence. The North Shields Naval Volunteer Corps and the Jarrow Engineer Volunteers were the first to establish a torpedo brigade, and their example has been followed in other parts of the country. The first object should be to make a careful survey of the coast and adjoining seas, and then to fix upon the proper localities for placing submarine mines. Those fired by contact would be the first to be called into requisition, as being both more easily managed and less costly. But, by degrees, the less dangerous system of electric torpedoes would be adopted, and a complete network of wires prepared ready to be laid at the shortest notice. The work of laying and removing the wires with the dummy engines of destruction would form one of the principal items of drill for the new corps. The acquisition of one or more swift cutters, armed with Gatlings if necessary, and provided with the apparatus for firing "spar torpedoes," would be the next step in the armament of a torpedo station; and the use of the Whitehead fish torpedoes and of electrically-steered launches would —at least, in the present state of this branch of naval warfare, complete the means of defence with which such stations ought to be fitted. The necessity for guarding against placing these powerful engines in the hands of any but the most responsible men would require the careful attention of the authorities; but, with proper regulations, there is no more reason why volunteer torpedo corps should not be formed and fully equipped than for preventing the use of cartridge by miners or the issue of ball cartridges to riflemen. Government should, at any rate, be prepared to meet the proposal which, as we have said, is receiving such active support in different parts of the country. The proper use of torpedoes as a means of defending our coasts would greatly reduce the capital expenditure necessary for the erection and arming of large and permanent earthworks and forts, as well as the annual outlay which the maintenance of these fortifications necessitates.

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DYNAMO-ELECTRIC MACHINES.

[CONCLUDED FROM P. 77.]

The true comparative measure of the efficiency of dynamo-electric machines as means for converting motive power into work derived from electrical currents, whether as light, heat, or chemical decompostion, is found by comparing the units of work consumed with the equivalent units of work appearing in the circuit external to the machine. In Table V, the comparative data are given. In the first column the dynamometer reading gives the total power consumed; from which are to be deducted the figures given in the second column, being the work expended in friction, and in overcoming the resistance of the air; although, of course, it must be borne in mind, that, that machine is the most economical in which, other things being equal, the resistance of the air and the friction are the least. The third column gives the total power expended in producing electrical effects, a portion only of which, however, appears in the effective circuit, the remainder being variously consumed in the production of local circuits in the different masses of metal composing the machines. This work eventually appears as heat in the machine. Columns four, five, and six give respectively the relative amounts of power variously appearing as heat in the arc, in the entire circuit, and as heat due to local circuits in the conducting masses of metal in the machine, irrespective of the wire. This latter consumption of force may be conveniently described as due to the *local action* of the machine, and is manifestly comparable to the well-known local action of the voltaic battery, since in each case it not only acts to diminish the effective current produced but also adds to the cost.

TABLE II.—RESISTANCES OF DYNAMO-ELECTRIC MACHINES.
From Determinations by EDWIN J. HOUSTON and ELIHU THOMSON.

NAME OF MACHINE.	Temperature in degrees F.	RESISTANCES. Of Machine + Conductor.	RESISTANCES. Of Arc + Lamp.	Resistance of conducting Wire.	Resistance of Lamp, exclusive of Arc.	CORRECTED RESISTANCES. Of Machine—conductor.	CORRECTED RESISTANCES. Of Arc—Lamp.	Total resistance of the Circuit. Ohms.	REMARKS.
A¹, Large Brush	73½	·485	·57	·016	·032	·483	·54	1·055	At beginning of run.
A¹ ,, ,, ...	88	·495	·82	·016	·032	·493	·79	1·315	After running 25 min.
A², Small Brush	74	1·255	1·70	·016	·032	1·239	1·67	2·955	Arranged for low resist.
A², ,, ,, ...	74	5·06		·016		5·044			,, ,, high ,,
B¹, Large Wallace......	74	4·60	1·93	·016	·032	4·584	1·95	6·53	Machine cold.
B¹, ,, ,, ...	118	5·13							After 40 min. run.
B², Small Wallace......	74	4·96	2·87	·016	·1025	4·944	2·77	7·83	At 844 rev.
B². ,, ,, ...	74	4·96	3·24	·016	·1025	4·944	3·18	8·24	,, 1000 rev.
Gramme	68	1·685	1·35	·016	·1025	1·669	1·25	3·04	Arc not normal.
,, ...	68	1·685	1·97	·016	·1025	1·669	1·87	3·66	Arc normal.

We desire to call attention to the fact that in all the determinations conducted by us we have been particularly careful to ensure a definite relation between the external and internal resistances in each case—a condition of paramount importance in the effective working of these machines. It is evident, indeed, that no determinations made with an unknown or abnormal external resistance can be of any value, since the proportion of work done, in the several portions of an electrical circuit, depends upon, and varies with the resistances they offer to its passage. If, therefore, in separate determinations with any particular machine, the resistance of that part of a circuit of which the work is measured be, in one instance large, in proportion to that of the remainder of circuit, and in another small, the two measurements thus made would give widely different results, since in the case where a large resistance was interposed in this part of the circuit, the percentage of the total work appearing there would be greater than if the small resistance had been used.

When an attempt has been made to determine the efficiency of a single machine, or of the relative efficiency of a number of machines, by noting the quantity of gas evolved in a voltameter, or by the electrolysis of copper sulphate in a decomposing cell, when the resistance of the voltameter or decomposing cell did not represent the normal working resistance, it is manifest that the results cannot properly be taken as a measure of the actual efficiency.

In Table II. it will be found that, in general, where the machine used had a high internal resistance, the arc resistance normal to it was also high, but they are not necessarily dependent upon each other. The arc resistance depends on the intensity of the current, the nature of the carbons, and on their distance apart. Other conditions being the same, the resistance of the arc is less when the current is great.

Since all the machines examined were built for lighting, it will readily be seen that, other things being equal, that machine is the most economical in which the work done in the arc bears a considerable proportion to that done in the whole circuit, and since, with any given current, the work is proportional to the resistance, we have in Table II. the data for comparison in this regard. For example, in the second determination of A¹, the large Brush machine, the resistance of the arc constitutes considerably more than one-half the total resistance of the entire circuit, while in B², the small Wallace-Farmer machine, it constitutes somewhat more than one-third the total resistance. These relative resistances give, of course, only the proportion of the current generated, which is utilized in the arc as light and heat, the conditions of power consumed to produce the current not being there expresssd.

During any continued run, the heating of the wire of the machine, either directly by the current, or indirectly from conduction from those parts of the machine heated by local action, as explained in a former part of this report, produces an increased resistance, and a consequent falling off in the effective current. Thus, in Table II., at the temperature of 73·5° Fahr., A¹, the large Brush machine had a resistance of ·485 ohm, while at 88° Fahr., at the armature coils it was ·495 ohm. These differences were still more marked in the case of B¹.

In A², the small Brush machine, it will be noticed that two separate values are given for the resistance of the machine. These correspond to different connections, viz., the resistance, 1·239 ohms, being the connection at the commutator for low resistance, the double conducting wires being coupled in multiple arc, while 5·044 ohms represent the resistance when the sections of the double conductor are coupled at the commutator in series.

Referring to Table III., the numbers given in the column headed "Heat in Arc and Lamp," are the measure of the total heating power in that portion of the circuit external to the machine. They do not, however, in the case of any machine, represent the energy which is available for the production of light, which depends also on the nature and the amount of the resistance over which it is expended. For example, the heat in arc and lamp are practically the same in each of the Brush machines, if the measurement of the smaller of these machines be taken at the higher speed. The amount of light produced, however, is not the same in these two instances, being considerably greater in the case of the larger machine. The explanation of this apparent anomaly is undoubtedly to be found in the different resistances of the arcs in the two cases. In the large Brush machine the carbons are nearer together than when the small machine is used. This suggests the very plausible explanation that the cause of the difference is to be attributed to the fact that, although the total heating effect is equal in each case, when the large machine is used the heat produced is evolved in a smaller space, and its temperature, and consequent light-giving power, thereby largely increased.

It would seem, indeed, that any future improvements made in the direction of obtaining an increased intensity of light from a

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given current will be by concentrating the resistance normal to the arc in the most limited space practicable, thereby increasing the intensity of the heat, and, consequently, its attendant light. It may be noted, in this connection, that in all the cases in which the resistance of the arc was low, the photometric intensity was high. This, indeed, might naturally be expected, since a great intensity of heat would, under existing conditions of the use of the arc, admit of increased vaporization, and consequent lowering of the resistance.

In the column headed "Total Heat of Circuit," are given the quantities of heat developed in the whole circuit, which numbers, compared with those in the preceding column, furnish us with the relative proportions of the work of the circuit, which appear in the arc and lamp. The column headed "Heat per ohm per second" gives the relative work per ohm of resistance in each case, and these numbers, multiplied by the total resistance, give the total energy of the current expressed in heat units per second.

TABLE III.—THERMIC EFFECTS OF DYNAMO-ELECTRIC MACHINES.
From Determinations by EDWIN J. HOUSTON and ELIHU THOMSON.

NAME OF MACHINE.	Galvanometer deflection with shunt.	Heating Effect in Arc and Lamp: Lbs. H_2O.	Heating Effect in Arc and Lamp: Increase degrees Fahr.	Heating Effect in Arc and Lamp: Duration of run.	Resistance of Calorimeter equal to arc.	Heat in arc and lamp, in pounds H_2O, 1° F.	Total heat of the circuit, in lbs. H_2O 1° F.	Heat per ohm, per second.	Speed of machine rev. per min.	Dynamometer reading including friction.
A^1, Large Brush	51¼°	18·64	23·25	10	·82	43·338	69·49	·881	1340	107806
A^2, Small Brush	34	18·63	9·09	5	1·70	33·87	58·87	·332	1200	117700
A^3, „ „	37	18·63	18·68	8	1·70	43·45	75·57	·426	1400	124248
B^1, Small Wallace	25¼	18·63	11·50	12	2·87	17·85	48·70	·104	844	97068
B^2, „ „	25¼	18·63	4·92	6	2·87	15·28	41·69	·089	844	97068
B^3, „ „	24¼	18·64	10·75	10	3·28	20·04	50·34	·102	1040	128544
Gramme	38	18·64	16·25	10	1·97	30·29	56·28	·256	800	60992

For conversion to new heat units—1lb. water, 1° F.,=259·185 grammes of water, 1° C.

In Table IV. are given the results of calculation and measurement, as to the electrical work of each machine. It is evident to those acquainted with the principles of electrical science, that in the veber current and the electromotive force, we have the data for comparing the work of these machines with that of any other machine or battery, whether used for light, heat, electrolysis, or any other form of electrical work.

As might be supposed, the values given in Table IV., of the veber current, approximate relatively to the photometric values, as will be seen from an examination of that part of the general report of the committee relating to photometric measurements.

The values of the veber current, as deduced from the heat developed, and from the comparison with a Daniell's cell, do not exactly agree; nor could this have been expected, when the difficulty of minutely reproducing the conditions as to speed, resistance, &c., is considered.

By comparison of the electromotive force of the different machines, it appears that no definite unit seems to have been aimed at by all the makers as that best adapted to the production of light.

Table V. is designed especially to permit a legitimate comparison of the relative efficiency of the machines, as well as their actual efficiency in converting motive power into current. The actual dynamometer reading, for which we are indebted to the sub-committee on the measurement of power, is given in the first column. On account of diffrences of construction and differences in speed of running, the friction and resistance of the air vary greatly, being least with the Gramme, as might be expected, since the form of the revolving armature, and the speed of the machine, conduce to this result. This is, of course, a point greatly in favour of the Gramme machine.

That portion of the power expended available for producing current is given in the third column, being the remainder, after deducting the friction, as above mentioned; but this power is not in any case fully utilised in the normal circuit.

TABLE IV.—CURRENT AND ELECTROMOTIVE FORCE OF DYNAMO-ELECTRIC MACHINES.
From Determinations by EDWIN J. HOUSTON and ELIHU THOMSON.

NAME OF MACHINE.	Veber Current per ohm per sec.: From heat developed.	Veber Current per ohm per sec.: By comparison with Daniell's batt.	Electromotive Force in Volts: Calc. from heat and resistance.	Electromotive Force in Volts: By comparison with Daniell's batt.	Per cent. of the work of current appearing in the arc.	Corresponding Dynamometric Values.	REMARKS.
A^1, Large Brush	30·97	29·87	39·94	39·28	60·08	107806	Speed 1340 rev.
A^2, Small Brush	18·63		55·05			117700	„ 1200 „
A^3, „ „	21·12	21·87	62·41	64·63	56·51	124248	„ 1400 „
B^1, Small Wallace	10·42	9·73	81·59	76·19	35·38	97068	„ 884 „
B^2, „ „	9·64		75·48				„ 844 „
B^3, „ „	10·33	11·16	85·12	91·98	38·59	128544	„ 1040 „
Gramme	16·38	16·86	59·95	61·71	51·09	60992	„ 800 „

This is found to be the case by comparing calculations of the total work of the circuit in foot-pounds, as given in the appropriate column, with the amount expended in producing such current. For instance, in the case of A^1, the large Brush machine, the available force for producing current is 89656 F.P. per minute, of which only 53646 re-appear as heat in the circuit. The balance is most probably expended in what we have termed *local action*—that is, the production of local currents in the various conducting masses of metal composing the machine. The amount thus expended in local action is given in the column designated "F. P. unaccounted for in the Circuit." A comparison of the figures in this column is decidedly in favour of the Gramme machine, it requiring the smallest proportion of power expended, to be lost in local action. When, however, we consider that the current produced by the large Brush machine is nearly double that produced by the Gramme, the disproportion in the local action is not so great. The columns containing the percentages

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of "Power utilized in the Arc," and "Useful Effect after deducting Friction," need no special comment.

Our conclusions are as follows:—

1. The Gramme machine is the most economical, considered as a means for converting motive power into electrical current, giving in the arc a useful result equal to 38 per cent., or to 41 per cent. after deducting friction and the resistance of the air. In this machine the loss of power in friction and local action is the least, the speed being comparatively low. If the resistance of the arc is kept normal, very little heating of the machine results, and there is an almost entire absence of sparks at the commutator.

2. The large Brush machine comes next in order of efficiency, giving in the arc a useful effect equal to 31 per cent. of the total power used, or 37¼ per cent. after deducting friction. This machine is, indeed, but little inferior in this respect to the Gramme, having, however, the disadvantages of high speed, and and a greater proportionate loss of power in friction, &c. This loss is nearly compensated by the advantage this machine possesses over the others of working with a high external compared with the internal resistance, this also ensuring comparative absence of heating in the machine. This machine gave the most powerful current, and consequently the greatest light.

TABLE V.—EFFECTS OF DYNAMO-ELECTRIC MACHINES IN FOOT-POUNDS PER MINUTE.
From Determinations by EDWIN J. HOUSTON and ELIHU THOMSON.

NAME OF MACHINE.	Dynamometer reading. F. P. consumed.	Friction and resistance of air.	F. P. consumed, after deducting friction.	F. P. appearing in arc as heat.	F. P. appearing in whole circuit.	F. P. unaccounted for in the circuit.	Per cent. of power utilized in arc.	Per cent. of effect after deduct. friction.
A¹, Large Brush	107606	17950	89656	33457	53846	38010	31	37¼
A², Small Brush	117700	12328	105372	26148	45448	59924	22	25
A³, ,, ,, ...	124248	14976	109272	33543	58340	50932	27	31
B², Small Wallace	97068	7800	89268	13780	37596	51672	14	15½
B³ ,, ,, ...	128544	11072	117472	15469	38862	78610	12	13
Gramme	60992	4512	56480	23384	43448	13032	38	41

For conversion into gramme-metres — 1 foot-pound = 138 gramme metres, nearly.

3. The small Brush machine stands third in efficiency, giving in the arc a useful result equal to 27 per cent., or 31 per cent. after deducting friction. Although somewhat inferior to the Gramme, it is nevertheless a machine admirably adapted to the production of intense currents, and has the advantage of being made to furnish currents of widely varying electromotive force. By suitably connecting the machine, as before described, the electromotive force may be increased to over 120 volts. It possesses, moreover, the advantage of division of the conductor into two circuits, a feature which, however, is also possessed by some forms of other machines. The simplicity and ease of repair of the commutator are also advantages. Again, this machine does not heat greatly.

4. The Wallace-Farmer machine does not return to the effective circuit as large a proportion of power as the other machines, although it uses in electrical work a large amount of power in a small space. The cause of its small economy is the expenditure of a large proportion of the power in the production of local action. By remedying this defect, a very admirable machine would be produced.

CORRESPONDENCE.

MR. EDISON'S CHARGE AGAINST MR. HUGHES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: We can safely predict what Mr. Edison will say in answer to the gentlemen he has so rashly accused; but we have facts enough before us already to form an opinion independent of—and, perhaps, in spite of—anything he can possibly say. Allow me to put them in the form of Questions and Answers:—

Q. When do we first hear of metallized charcoal being used?

A. In 1801, by Sir H. Davey, to render that substance a good conductor.

Q. When do we hear of carbon being first used for the purpose of varying the resistance of an electrical circuit?

A. In 1866, by Mr. Clerac, who made the fact publicly known then, and again in 1873.

Q. Are more recent claims now put forward in respect to these two materials?

A. Yes; Mr. Edison distinctly claims both.

Q. How do Edison and Hughes stand in respect to the *use* of these materials?

A. Edison begins and ends with them. Hughes begun and ended with neither; he merely used them incidentally—in a way and for a purpose quite different from Edison.

Q. What, then, does Edison claim to have discovered, using these substances?

A. An articulating telephone worked by a voltaic current, and something that he calls a thermopile.

Q. Is this the thermopile that he says Hughes has stolen from him?

A. Not the same, but something possessing thermoscopic qualities; there are many such. Hughes noticed them in passing, and the papers announced the fact. But Hughes himself did not publicly mention it, for it had no bearing upon his microphonic researches. It is not a thermopile; and, for what it may be worth, Mr. Edison's claim to his own is not disputed.

Q. Now as to the telephone, has Edison discovered anything?

A. Certainly not. Professor Graham Bell discovered the requisite conditions, and perfected them. Edison, for the purpose of fulfilling them in another way, adopts carbon—the properties of which were already known—in order to vary the resistance, so that voltaic currents may be used instead of magneto currents. He then takes Professor Bell's diaphragm and makes it actuate the carbon—that is all! Finding the diaphragm too energetic, he makes it thicker, and he calls this a discovery—the fact being that the diaphragm had no business there at all. It is a very imperfect instrument even then, and its main idea is to evade Professor Bell's patent.

Q. Has Professor Hughes made a telephone?

A. Yes; and a veritable discovery, too. Working upwards, he found that points of contact at all discontinuous surfaces respond electrically to articulatory vibrations. This was the result of reasoning and of progressive investigation; he consequently never reached the diaphragm stage; while Mr. Edison, on his part, never got behind it. The microphone, used as a speaking transmitter, is an absolutely perfect instrument.

Q. How does the microphone proper stand in relation to Mr. Edison's claims?

A. Nowhere. This mode of reproducing feeble sounds is altogether novel, and a real discovery. Other people, no doubt, have been working in the same direction—Mr. Scott, for example, but not Mr. Edison, whose special aptitude, if we may judge him by his telephonic essay, is to adapt, alter, and appropriate other people's discoveries. He is *now* calling in reporters to listen to the tread of a gnat!

Q. Then, how do you account for all this rumpus and recrimination?

A. By the fact that Mr. Edison is the paid inventor to a big American telegraph company, and he acts as if he had prescriptive rights in the field of discovery. He hears that Mr. Hughes has discovered an extremely sensitive thermopile, and he straightway jumps to the conclusion that Mr. Preece has betrayed his secret, when, in fact, there was no secret to reveal; what was known to Preece was known by everybody, and Hughes has not meddled with it.

This, sir, is how the matter strikes me as a looker-on. If any of your readers deny the orthodoxy of my catechism, I shall be glad to consider their correction.

JUDEX.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

We cannot undertake to return drawings or manuscripts, and must, therefore, request Correspondents to keep copies.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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THE ELECTRICIAN *can be had, by order, from any newsagent in town or country, at the various railway stations; or it can, if preferred, be supplied direct from the office, on the following terms (paid in advance):—*

Quarterly	4*s.* 10*d.*
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NOTICE TO EDITORS.

We shall be happy to exchange with the Editors of Scientific journals who receive the first numbers of THE ELECTRICIAN.

Nous serons heureux de faire l'échange avec Messieurs les Rédacteurs des Journaux scientifiques qui recevront les premiers numéros de L'ELECTRICIAN.

Es wird uns ein Vergnügen sein mit den löblichen Redactionen der deutschen und anderen continentalen Journäle und Zeitschriften, denen die ersten Nos. des ELECTRICIAN *zu Händen kommen möchten auszutauschen.*

I Signori Editori di giornali scientifici che riceveranno i primi numeri dell' ELECTRICIAN *ci faranno cosa gradita accettando il cambio che loro offriamo.*

DISPUTED INVENTION OF THE MICROPHONE.

The true philosopher is large hearted: he may have a momentary feeling of regret to find his choicest thoughts forestalled by another worker in the same direction, but the feeling soon passes away, and he is among the first to congratulate his brother investigator. Thus, also, it is with true science. Frequently, however, the worker, who, if left to himself, would shun popularity and controversy, especially the latter, is compelled to put aside the work he delights in and enter the field he abhors. Inconsiderate friends are too often the cause of trouble, and by their ignorance or officiousness do a vast amount of harm. We are not all Sir Isaac Newtons, and hence do not understand the miserable littleness of our knowledge. The wisest know how vast the unknown really is, but many not so wise are apt to think much of their knowledge and themselves, and seize every opportunity to air their unfledged opinions. This, unfortunately, is the case in the controversy relating to the microphone. Our literary cousins across the Atlantic, who evidently know little or nothing of electrical science, do not hesitate to utter dicta couched in forcible, if not very convincing language, and we are sorry to see that one of our English contemporaries has given way to a similar practice. We should much prefer to pass this by unnoticed, but, having been the first English paper to call attention to certain charges brought forward by Mr. Edison, we feel compelled to protest against such reasoning as has been put forward by our contemporary. On June 22nd we called attention to Mr. Edison's charges, and the same week our contemporary, singularly enough, had a long article the object of which was to show that the discoveries of Edison and Hughes were different. However, in the course of the article the writer confesses that "Mr. Edison was sailing round and very near to the discovery of Prof. Hughes;" . . that "the *independent* (the italics throughout this article are ours) discovery made by Mr. Edison was that carbon, etc.;" . . that "it will be seen Mr. Edison's discovery *is but a special case of the larger and more comprehensive discovery* of Prof. Hughes." The same paper on July 5, in a long article as full of glaring errors as a porcupine's back is of bristles, says, "The chief difference between the two discoveries is that the latter (Hughes's) is comprehensive and broad, and *may be said to include the former* (Edison's), which is special and narrow, and refers to but one substance out of an infinite number." . . "The use of carbon is *essential* to Mr. Edison's instrument, but it is only one of a thousand substances which can be employed in the microphone." Will it be believed that this infallible writer, after admitting that Edison has discovered a "special case," and that Hughes's discovery "may be said to include Edison's," goes on to say, "The two inventions *are essentially different in every way, and entirely independent of one another,*" and has the audacity, not to speak of the bad taste, to write that "it is not too much to say that Mr. Edison's name is familiar in this country and on the Continent of Europe entirely through the friendly and gratuitous exertions of Mr. Preece?" After this admirable piece of logic, which is really far from being the *best* example we could have taken, and perhaps shall have to take, from these pages, the articles culminate in an editorial which causes us to blush for English journalism. Before, however, giving extracts we must call attention to a fact, viz., that Mr. Edison's discovery is no more a thermopile than is Prof. Hughes's. Both are thermoscopes. Professor Hughes saw this, and, with the magnanimity so characteristic of great men, immediately declined to claim the discovery as original. Our contemporary is so blind that it cannot see the fact that calling a thermoscope a thermopile does not make it one. Professor Hughes's discovery shall be a thermoscope, and Mr. Edison's shall be a thermopile. The harping upon this word when the honour of scientific men is at stake shows clearly what we must expect from such as strain at a gnat and swallow a camel. The peculiar feature of the article we shall now consider is the reference to *private* letters. Mr. Edison quotes, as will be seen in another column, a letter from Mr. Preece, and our commentator says: "Mr. Preece is *made* to say in a letter that the researches of Professor Hughes and the experiments of Mr. Edison are so much alike that it is difficult to distinguish between the two, *whereas if the whole letter were given an altogether different impression would be conveyed.*" Has our contemporary *seen* this letter? If the letter has been seen, why is it not published? Is it sufficient that our contemporary should know its contents when others, among whom are men capable of judging of its value, are anxious to see this question settled? The last column of the article consists of "bathos run mad." We cannot quote a single sentence.

Science is cosmopolitan, and they of the scientific world are—

> Men, my brothers, men the workers, ever reaping something new,
> That which they have done but earnest of the things that they shall do.

Most of us are convinced that Professor Hughes has made the grand discoveries with which he is credited, quite independently of all that Mr. Edison has done, and if Mr. Edison *can* prove that he had discovered the same thing previously, Professor Hughes is not the man to claim more than he is entitled to, but will be the first to credit Mr. Edison with whatever honour is his due. Under these circumstances even, Professor Hughes would be entitled to the honour of independent discovery and of having brought the discovery nearer perfection. The question, then, is, can Mr. Edison prove his

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claims? Is his instrument, or any instrument previously constructed by him, similar to that of Professor Hughes? If not, and we do not feel disposed to give an answer in the affirmative before having the whole of the details before us, Professor Hughes will be entitled to be credited with the whole work and the priority of discovery. The charge against Mr. Preece, as we understand it, is one which demands a more detailed denial than it has at present received. We believe Mr. Preece to be incapable of the action ascribed to him, and it is almost certain that he has acted throughout in good faith to Edison. It is, nevertheless, a fact, that many people who listened to his speeches on the subject went away with the idea that he was thoroughly conversant with all Professor Hughes's experiments throughout the whole period of their continuance. Assuming, then, that there is some similarity between the discoveries, would it not be well, once for all, to put on record the exact dates when Mr. Preece first heard of and received full information regarding Professor Hughes's work. We have been informed that Mr. Preece was ignorant of Professor Hughes's work till it was practically completed, and if this is correct the charge of "breach of confidence" falls to the ground. Our contemporary, *Engineering*, in its attempts to deal with matters which are not exactly germane to its columns, has signally failed to put forward the true facts of the case. In its laboured advocacy it has given expression to such a confusion of ideas that the cleansing of the Augean stable physically was a labour indeed easy, compared with that which we have to perform mentally to understand what it means.

ON THE STUDY OF ELECTRICITY AS A PROFESSIONAL PURSUIT.

BY THOMAS T. P. BRUCE WARREN.

VI.

Chemistry, as a branch of science to which the electrical student should direct his attention, has been so completely omitted by recent writers on this subject that I shall devote a few papers to the consideration of chemistry in its general technological relation to telegraphy.

I shall presume that the reader has gathered a tolerably fair knowledge of chemical manipulation, and is familiar with the general use of apparatus, the meaning of the more common terms used in analysis, &c.; and, if not already conversant with the chemical properties of the materials with which he is in daily contact, will endeavour to do so at once. Electricians generally look upon chemistry as a science so extensive that to attempt to comprehend it fully requires more time than can be well spared for this purpose. It takes no great amount of time, and involves little expense, to make one's self familiar with the general principles of chemistry. The general chemist has frequently to deal with substances the nature of which is only revealed to him by the careful interpretation of their behaviour with other substances. The electrician need not be surrounded with such wide margins of thought; the substances with which he has to deal should present little or no mystery. If he is called upon, for instance, to examine a battery residue, he can always find out beforehand what materials have been put together; he has then to consider what changes are likely to have taken place, according to the affinity choices which the substances themselves appear to indicate. When, for instance, several basic substances are mixed together with an acid the quantity of which is insufficient to convert them all into salts, such bases which have the greatest affinity for the acid will take up what they require, and those having the weakest affinity will come in for what is left. The general acceptance of this principle is not quite certain. There are some conditions under which this partition of an acid may be modified, however, if the electrician will only master the little which is necessary of affinity, his taste for the science will be sufficiently stimulated that he will have nothing to dismay him in his onward course. It is not necessary to have a room fitted up as a chemical laboratory, so long as acid vapour makes its escape without entering the room. Every possible care should be taken to ensure the protection of electrical apparatus. A spacious cupboard, well-ventilated into a chimney, ought to be at the disposal of the electrician. The ordinary reagents required in actual work, and nothing more, should be kept at hand.

It is usual in laboratories to have a separate room for the chemical balance, since it may suffer from the fumes of acid. This is not necessary, as the balance could be conveniently fitted up in the electrical instrument room. On a large scale, however, it is indispensable to have a properly-fitted up suite of rooms so as to include furnace operations and combustions.

The apparatus necessary should include a few beakers, flasks, test tubes, porcelain dishes, funnels, graduated measures, burettes, a drying oven, iron pestle and mortar, and a porcelain mortar, a few watch glasses, dessicators, and for special operations such contrivances which will be mentioned in their proper places.

There are several cases where volumetric methods of analysis are extremely serviceable and reliable, and these should always have the preference over the other methods of "precipitating and weighing; or, as it is called, the "gravimetric."

Distilled Water.—The electrician requires distilled water for cleaning out the quadrant and portable electrometers of Sir William Thomson; it is also necessary for cleaning the ebonite portions of apparatus which have become defective in insulation, from being coated with a film of sulphurous acid by oxidation of the sulphur contained in it. On cable expeditions I have carried a small still, so as to prepare distilled water for the use of these instruments in places where it might not be procured. Distilled water, if not carefully drawn over contains impurities. Condensed water obtained on board ship is almost certain to be contaminated. The coloration of the water after a few moments, when a few drops of the Nessler reagent are added, indicates the presence of ammonia, which is due to the decomposing action of heat on the nitrogenous matter contained in the water. Nitrate of silver solution, when added to water containing chlorine or chlorides, becomes turbid. Water so contaminated to any great extent is unfit for cleaning purposes. A slight turbidity on the addition of nitrate silver need not lead to the rejection of the water for this purpose. The presence of ammonia, however, can not be regarded with such indifference, more especially if accompanied with chlorine. In this country rain water, if collected during a heavy shower, sufficient time being allowed to clear off the dust and soot from the roofs, will contain only slight traces of sulphate of lime dissolved from the slates; but, as the materials used generally for roofing in foreign countries encourage the deposition and growth of organic "filth," such a source is obviously of no use to the electrician. In a locality where the water supply is of a doubtful character for drinking purposes, it would be well for sanitary considerations to include a two-gallon still in the outfit for a foreign station. This might easily yield from eight to twelve gallons of distilled water per diem. Distilled water may be obtained from drug dealers, but, as it is sometimes obtained from the condensed water from engines, care must be taken that it has not been contaminated with the grease from the pumps; its flavour, or its action on the motions of small pieces of camphor when thrown into it will prove the absence or presence of this contamination. Where the natural water of any locality contains an unusually large proportion of lime and magnesium salts, the advantage of distilled water for the use of batteries is obvious. On board ship the condensed water used for drinking purposes would be used. The addition of milk of lime or hydrate of baryta will precipitate lime, iron, magnesia, alumina, silica, and organic matter from water, and may be of some use in rendering water, abnormally rich in these impurities, toleraby pure. The lime acts by absorbing the free carbonic acid in the water; the sulphates would, unless very plentiful, be still held in solution. Baryta would, however, remove the sulphates as well. In cases where water contains a large quantity of lime it would be well to ascertain how far the same may be improved for uses in batteries by removing the lime by the cautious addition of oxalic acid or oxalate ammonia. The electrician may sometimes require to know approximately the amount of lime and magnesia contained in a sample of water. The following is most convenient, so long as the quantities of iron and other salts which affect the hardness of water are not large. Ascertain, first, by means of the standard soap test, the total hardness of the water. To a similar quantity of water, add oxalate of ammonia so as to remove the lime, filter, and to the filtrate add the soap test cautiously until the usual lather appears. This quantity subtracted from that first used will give the amount corresponding to the lime; the number of measures required in the second case multiplied by $\frac{42}{75}$ will express the degrees of magnesian hardness. If, then, we start with a solution of soap standardised, so that a given measure represents one

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grain of lime per gallon, the number of measures used will give the total number of grains per gallon. The reader had better purchase standard solutions, or have the assistance of some experienced friend in their preparation. A very convenient way of obtaining tolerably pure water from a supply abnormally hard is to add cautiously some recently-prepared baryta water until precipitation ceases, and to remove the excess of baryata by the addition of sulphate of zinc or copper or mercury, according to the nature of the salt which it is wished to dissolve.

The faults in batteries due to inconstant currents may arise from the accumulation of air and carbonic acid on the under side of the zinc, and which are readily taken up by water, even when distilled, unles kept in closed vessels. It is, therefore, well to use boiled water for any description of constant cell. Boiling will expel air; and the carbonic acid and such impurities which exist as carbonates, and are held in suspension by the carbonic acid, will, in consequence, be precipitated. Taking, for illustration, the water supplied by the East London Water Company, I find the hardness before boiling, expressed in grains of carbonate of lime per gallon, to be sixteen, and after boiling it is reduced to three, of which two represent the hardness due to sulphates and other earthly salts soluble in water. I find that water holding in solution a large quantity of alkaline or earthy chlorides will after some time produce on the copper plates of a Daniell battery a copious deposit of chloride of copper. In certain cases the electrician has to provide against the deposition of water in the form of moisture on his instruments and connections, as when testing on board ship or any damp place. The use of sulphuric acid with electrometers is an instance of this application of dessication. Many crystalline salts contain water of crystallisation and constitution, which, of course, is always definite in the pure salts, but which, nevertheless, is sometimes much in excess; thus sulphate of copper may contain from 3 to 5 per cent. accidental water, as it may be termed, from being imprisoned among the crystals. Such cases are not numerous, but it is necessary to notice this, and care must be taken in purchasing, that water be not bought instead of the salt.

India-rubber and gutta-percha are also capable of absorbing water, and it is a matter of importance to the electrician to be able to ascertain readily whether a sample of any particular insulator contains more water than the circumstances connected with its manufacture should permit. Again, the penetration of water into the substance of an insulator is a most important matter to determine, for upon this depends the suitability of a material as a durable insulator in water. The manufacturer of submarine cables buys hemp, jute, manilla, and similar fibres, all of which may come to hand more or less damp, vegetable fibres being particularly hygroscopic. If we take the principal long cables which have been laid, we may, without any exaggeration, consider that manufacturers have paid over £200,000 sterling for water in this form.

Special methods are required to estimate the amount of water in different materials; but, as it is my intention to deal only with those cases in which the electrician is interested, I would recommend the reader who would wish to make his appliances for this purpose as complete as possible to consult some good work on chemical manipulation. Much may be learnt from the perusal of catalogues, to be obtained from most manufacturers and dealers in chemical apparatus.

As a preface to what is to follow on this part of my subject, it may be necessary to say that the metric system of weight and measure will be adopted, and, where it is necessary to refer to temperatures, the Fahrenheit scale will be used. I would caution the experimenter against taking for granted the purity of the chemicals he may purchase for analysis. In testing, let everything be done in order and with some predetermined object, keep your imagination in the background, and confirm your deductions by an appeal to facts, not fancy. In this way, and by paying attention to cleanliness and order, the experimenter need never feel in doubt as to the issues of his enquiry.

(TO BE CONTINUED.)

STUDENTS' COLUMNS.

ON SOME FORMS OF ENERGY AND THE CONNECTION BETWEEN THEM.

BY GEO. SMITH, B.SC.

[CONCLUDED FROM P. 104.]

If we take one pound of ice at 0° and heat it, observing the quantity of heat expended and the temperature produced, we shall find that for the first 79¼ thermal units expended the temperature will remain unaltered, but the ice will be converted into water, for the next 100 thermal units the temperature of the water will be raised to 100°, and that for the next 537 thermal units the temperature will remain at 100°, but the water will be converted into steam. When the ice is converted into water at 0°, or the water into steam at 100°, the heat is termed latent heat, because it is not sensible to a thermometer; it does not exist as actual energy, for ice and water at 0° radiate heat or energy with equal facility as do water and steam at 100°; it must exist as potential energy.

Now 79¼ thermal units $= 1390 \times 79\frac{1}{4} = 110,157\frac{1}{2}$ foot-pounds, and this amount of energy is expended in fusing one pound of ice, and is given up again on one pound of water becoming ice. As water expands so little during freezing, and this energy is expended in such a small space, this will account for the enormous pressure exerted by water in freezing. Most of the next 100 thermal units exist in the water as actual energy; but, as the water has sensibly expanded, and so its particles have been moved apart, some of the energy must have been rendered potential. This expansion will probably account for the fact that bodies have different specific heats at different temperatures. The next 537 thermal units, in like manner, exist in the steam as potential energy.

What has been the condition of the substance in the three states of solid, liquid, and gas? As already stated, every body is supposed to be made up of molecules, and, if the body possesses any of the actual energy of heat, these molecules are in a state of motion. In solids it is supposed that the molecules do not move far from their average position; in liquids it is supposed that they do move, to a very great extent, among one another, but that they are always colliding with their neighbours; and, thus changing the direction of their motion, they have a very short free path. In gases, on the other hand, it is supposed that the molecules have comparatively long free paths, and that they collide with their neighbours far less often. The work done in converting solids into liquids seems to be expended in moving the molecules so that they shall not entangle one another; that done in converting liquids into gases seems to be expended in moving the molecules to comparatively immense distances from one another.

It will be remembered that a gas expands when it is heated; generally speaking, a gas expands through $\frac{1}{273}$ of its volume at 0° for each degree through which its temperature is raised, and contracts $\frac{1}{273}$ of its volume at 0° for every degree through which its temperature is lowered. Will the volume of a gas vanish at —273°? We cannot say that, but we may imagine that at that temperature the gas possesses no heat, that its molecules are absolutely at rest, and that this temperature is the absolute zero.

When one pound of hydrogen burns or combines with eight pounds of oxygen, there is given off about 34,000 thermal units of actual energy. This enormous quantity, 34,000 thermal units, or more than 47¼ millions of foot-lbs. of energy existed in the mixture of hydrogen and oxygen as potential energy; during the combination the molecules rushed together, the energy became actual and capable of performing the amount of work represented by 47¼ millions of foot-pounds, and it would require an equal amount of work to tear those molecules apart again.

Carbon also burns in oxygen, and it may do so in two distinct stages. Thus 12lbs. of carbon may unite with 16lbs. of oxygen and form the gas carbonic oxide, during the combustion 25,000 thermal units are rendered actual. But this 28lbs. of carbonic oxide will again burn, combining with another 16lb. of oxygen, forming carbonic dioxide, and rendering an additional 69,000 thermal units actual. How is it that in combining with the first 16lb. of oxygen only 25,000 thermal units, and with the second 69,000 thermal units become actual energy? In the combination of tin and phosphorus with oxygen each atom of oxygen in the combination causes the same amount of energy to become actual; we are, therefore, justified in assuming that the last atom of oxygen should set free only as much energy as the first, and yet, apparently, 69,000—25,000=44,000 thermal units do not appear in the first case that do in the second. But, as carbon is a solid, and carbonic oxide and dioxide are both gases, it seems extremely probable that these 44,000 thermal units, or more than 61 millions of foot pounds, are rendered potential energy in order to cause the solid carbon to assume the properties of a gas.

Seventy-six pounds of carbon disulphide consist of 12lb. of carbon and 64lb. of sulphur: now, these 12lb. of carbon in combining with 32lb. of oxygen produce, as we have seen, 94,000 thermal units, and the 64lb. of sulphur combining with 64lb. of oxygen produce 142,000 thermal units; thus we see that when a mixture of 12lb. of carbon and 64lb. of sulphur are burnt it produces a total of 236,000 thermal units of actual energy. But if 76lb. of the chemical compound carbon disulphide are burnt we have 258,000 thermal units, or 22,000 thermal units more rendered actual; and it is evident that these 22,000 thermal units

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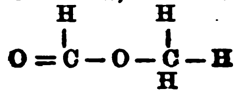
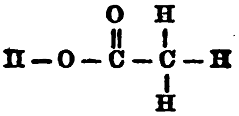
were rendered potential, or were absorbed when the atoms of carbon and sulphur combined to form the carbon disulphide. In a somewhat similar manner, such explosives as nitroglycerine, guncotton, &c., possess a great store of potential energy which is rendered actual at the moment of explosion.

As the potential energy of compounds differ, we may expect that the potential energy of compounds of the same ultimate but different proximate constitution will not be the same: methylic formate and acetic acid have the same ultimate formula, $C_2H_4O_2$, but different proximate formulæ, as shown below:—

Methylic formate 

Acetic acid 

Sixty pounds of the first on combination with oxygen gives off 252,000 thermal units of actual energy, while 60lbs. of the second gives off only 210,000. The difference is probably due to the fact that it requires the expenditure of less energy to force asunder the carbon atoms in the first than in the second case.

Now, consider what happens in a simple galvanic cell, one consisting of copper, dilute sulphuric acid, and zinc, having its poles connected by a short thick copper wire, or, better still, suppose the copper and zinc plates to touch in the liquid, and suppose that in a certain time the zinc plate has lost ·65lb. in weight, or, in other words ·65lb. of zinc has been converted into zinc sulphate. If ·65lb. of zinc be burnt in oxygen, it forms 81lb. of zinc oxide, and liberates 835 thermal units as actual energy, and, if this zinc oxide combines with sulphur trioxide to form zinc sulphate, it liberates another 205 thermal units, in all, 1,040 thermal units; but to do this in the cell, ·02lb. of hydrogen must be given off, torn away from the atoms with which it is combined; this requires the expenditure of an amount of energy represented by 680 thermal units, leaving 360 thermal units to represent the energy rendered actual in the cell by the solution of 65lb. of zinc. Now, this energy first takes the form of an electric current along the short thick wire, and if we suppose that 65lb. of zinc are dissolved in six hours, we shall have the current strength represented by 360 thermal units in six hours, or the thermal unit, equal to 1,390 foot-pounds, per minute. We thus see that the current strength depends simply on the combination of the electropositive element of the cell. The more rapidly the electropositive element is dissolved the greater will be the current strength, and in the same proportion. Whatever causes the solution of the zinc is called the electromotive force. Thus the greater the electromotive force the more quickly will the zinc be dissolved, and the greater will be the current strength. The greater the resistance interposed for the current to overcome the more slowly will the zinc be consuumed, and the less will be the current strength. By Ohm's law $C = \frac{E}{R + r}$, which simply expresses in another way that the current strength varies with the amount of zinc consumed.

In the ·65 lb. of zinc in contact with the sulphuric acid there are, as we have seen, 360 thermal units, or about half-a-million foot-pounds of potential energy; when the current passes, this potential energy is gradually converted into the actual energy of the current. What becomes of it? If the poles are connected by a short thick copper wire, it is only converted into the actual energy of heat which appears in the cell. If the poles are connected by a long thin wire which is immersed in water, the resistance of the wire being equal to that of the cell, still the actual energy of the current is converted into the actual energy of heat, one half of which appears in the cell, the other half in the water and wire, and, speaking generally, when no actual energy is changed into potential energy, the actual energy is distributed as heat to the different parts of the circuit in the proportion of their several resistances.

If the poles of the cell are connected with the electrodes of a voltameter, we shall find that, for every ·65lb. of zinc consumed in the cell ·02lb. of hydrogen should be liberated in the voltameter; but the potential energy of ·65lb. of zinc in sulphuric acid is 360 thermal units, while the actual energy of 680 thermal units is required to set free ·02lb. of hydrogen. We thus see that it is impossible to decompose water with one copper-zinc couple; but, if two such cells are joined in series, so that their currents flow in the same direction, the actual energy produced by the combination of ·65lb. of zinc in each cell is 720 thermal units. This is more than sufficient to decompose the water—in fact, 40 thermal units in excess. With this arrangement, 680 thermal units are used up, rendered potential, in setting free ·02lb. of hydrogen and 40 thermal units push on the current and are ultimately converted into actual heat energy. By increasing the number of cells in the series we increase the electromotive force, the strength of the current, and the rapidity of decomposition; but the excess of energy produced by the solution of the zinc is not converted into potential energy, but is wasted as heat.

The same argument is true as regards the decomposition of solutions of the metals, as copper sulphate by means of platinum electrodes; a certain amount of actual energy of the current is converted into potential energy of chemical attraction, and the excess appears as heat. But, if a solution of copper sulphate be decomposed by means of copper electrodes, as in electro-deposition of copper, as much copper will be deposited upon the one electrode as will be dissolved from the other; that is, as much potential energy is rendered actual at one electrode as actual energy is rendered potential at the other. No work is done in decomposing the solution, and the whole of the actual energy of the current is converted into the actual energy of heat, which is distributed in the different parts of the circuit.

If many cells be connected, with unlike plates together, in series, the terminals or poles will be found to exert attraction upon light bodies. This attraction can be measured just as in the case of gravity. But this property may be examined much better in the electricity produced by the various kinds of electrical machines, in which molar energy is converted into the energy of electricity. Not that there is any difference in kind, but the electricity of the cell may be compared to a large volume of fluid whose depth is small, and which is therefore only capable of overcoming small resistances, or exerting small pressures but for a long time. On the other hand, the electricity of the machine may be compared to a thin, tall column of water, which can overcome great resistances, but for only a short time.

The electricities of the two poles differ. One is termed positive, the other negative; two bodies charged with like electricity repel each other, those charged with unlike electricity attract one another. With the phenomena of attraction we have, exactly as in gravity, lines of force, potential, equipotential surfaces, intensity of attraction, &c.; and the energy, actual or potential, of bodies is measured in the same manner, but with smaller standards. The phenomena of repulsion are very similar to those of attraction, substituting motion from instead of motion to.

The wire through which an electric current passes attracts small masses of iron, &c., but the phenomena attending this form of energy are much better studied by the aid of magnets. As in frictional electricity, magnets have a power of attraction for unlike and repulsion for like poles. We therefore have lines of force, potential, &c., exactly as in gravity and electricity. The units used are of the same magnitude as those used with frictional electricity.

SIR: In reading Mr. Smith's otherwise excellent paper, I feel inclined to ask him for further explanation for his usage of the term energy. In his third paragraph I read "that word is energy."

The *force* of the attraction of gravity, or simply the *attraction* of gravity (this being a force or *pull*) varies inversely as the square of the distance between the centres of gravity of the masses between which the attraction is centred. But the *energy* of gravity in relation to a given body varies as the product of the force into the distance through which it can act, energy being always potential work, as work is always potential energy. The energy of attraction consequently increases as the distance between two masses is augmented, whilst, on the other hand, the force of gravity diminishes. D. F.

TELEPHONE AND MICROPHONE.

THE CONTROVERSY ABOUT PRIORITY OF INVENTION

MR. EDISON REPLIES TO MESSRS. PREECE AND HUGHES.

To the Editor of the Tribune.

SIR: In reply to the card of Messrs. Preece and Hughes, regarding the piracy by the latter of my carbon telephone, as contained in your paper of this date, allow me to refute their statements by their own words, and by extracts from the English scientific papers. I quote from their card:—

Hughes has not brought out any thermopile.

W. H. PREECE.

I emphatically indorse every word of the above message.

D. E. HUGHES.

From the Engineer, May 17, 1878.

Professor D. E. Hughes's telephone, microphone, and thermopile * * * A discovery not made till after Professor Hughes's paper was read before the Royal Society, points out another field of usefulness for this instrument.

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We all know what excellent service the thermopile has done in the hands of Professor Tyndall and other investigators of heat, but we think we may safely describe another kind of thermopile, as sensitive and far less complicated, less difficult to construct and less expensive than that compounded of zinc and antimony in the usual fashion. Instead of the glass tube as described, Professor Hughes was experimenting with a quill, and found that the instrument was exceedingly sensitive to heat. On the approach of a warm hand the galvanometer needle swings violently in one direction; on cooling, the tube swings in the other.

Again I quote from an article on the Telephone and Phonograph from the *Washington Star*, April 19, 1878:—

My carbon telephone may be used as a heat measurer (thermopile). It will detect the 50,000th part of a degree Fahrenheit, etc.

This paper was mailed to Mr. Preece April 20, 1878, and I prove that he recived it by quoting from the same article the following:—

The phonograph will preserve the exact pronunciation. The president of the Philological Society means to travel with it amongst all the North American tribes.

I quote from a lecture delivered by Mr. Preece before the Society of Arts, May 10, 1878, and published in their journal, page 537:—

The phonograph will preserve the exact pronunciation. The president of the Philological Society means to travel with it amongst all the North American tribes.

To set at rest the claims of Hughes on this subject, I quote from a letter received by me a short time since from Professor Langley, the eminent astronomer:—

Allegheny Observatory, June 4, 1878.

In response to your inquiry, I may state that, to the best of my recollection, in October, 1877, at your laboratory in Menlo Park, on my telling you that an instrument more sensitive to radiant heat than the bismuth-antimony linear pile was desired by me for certain researches in the spectrum, you suggested the use of carbon, of which you were showing Professor Barker and myself specimens. As well as I remember, the idea you gave me was that the common small thermopile was capable of developing little energy. The variation of resistance of the carbon under the influence of pressure or traction from a small heated adjacent body might be made to control the energy of a battery of any size, and thus multiply the sensitiveness of the pile almost without limit.

Mr. Preece, in his card, says:—

His (Hughes's) microphone is quite a different instrument to Edison's telephone.

Hughes, in his original paper of May 8, 1878, after summing up the labours of others, says:—

It will be seen, however, that in the experiments made by myself, the diaphragm has been altogether discarded, resting as it does upon the changes produced by molecular action, and that the variation in the strengths of the current flowing are produced simply and solely by the direct effect of its sonorous vibrations.

I quote from *The Journal of the Telegraph*, April 16, 1878 (of which paper Mr. Preece is a subscriber), an article taken from the proof sheets of Mr. Prescott's book on the telephone and phonograph, which reads as follows:—

In the latest form of transmitter which Mr. Edison has introduced, the vibrating diaphragm is done away with altogether.

From this book, which is now published, I quote from page 226:—

I (Edison) discovered that my principle, unlike all other acoustical devices for the transmission of speech, did not require any vibration of the diaphragm. That, in fact, sound waves could be transformed into electrical pulsations without the movement of any intervening mechanism.

This statement by myself, for publication in Mr. Prescott's book, was written over four months ago.

I quote from a letter from Preece to myself dated London, May 23, 1878:—

Hughes's doings border very closely upon yours, and it is difficult to distinguish between what you have done and what he has done.

Again, Mr. Hughes, after describing a number of experiments, sums up and says:—

Carbon is used in preference to any other material. * * * It is quite evident that these effects are due to a difference of pressure at the different points of contact.

I quote from *The Journal of the Telegraph*, April 16, 1878:—

By constant experimenting Mr. Edison at length made the discovery that, when properly prepared, carbon possessed the remarkable property of changing its resistance with pressure, and that the ratios of these changes, moreover, corresponded exactly with the pressure.

The same discovery was published in *The Scientific American* of July 17, 1877, *Journal of the Telegraph*, July 15, 1877, *Harper's Magazine*, December, 1877, and many other papers, both in this and other countries.

I quote an extract from a letter addressed to Sir Henry Thompson, the eminent surgeon, a copy of which was kindly sent to me by the writer:—

Hotel Chatham, Paris, June 7, 1878.

MY DEAR SIR HENRY: * * * It is certain that, at the meeting of the British Association at Plymouth last September, a method of magnifying sound in an electric telephone was described as having been invented by Edison, which was identical in principle and in some details with that brought forward by Hughes.

(Signed) WILLIAM THOMSON.

Finally, Mr. Preece had ample knowledge, through my correspondence with him, of all I had been doing since he left America, and had my telephones in his possession at least a month before the alleged discovery by Hughes, and it is almost impossible to attribute his failure to defend me (as he was bound to do) against the piracy of Hughes to his not understanding so simple an instrument, and the principle involved therein.

Mr. Preece says in his card of yesterday:—

I am in no way whatever a coadjutor of Hughes.

I quote from Hughes's original paper announcing his alleged discovery:—

My warmest thanks are due to Mr. W. H. Preece, electrician of the Post Office, for his appreciation of the importance of the facts I have stated, and for his kind counsel and aid in the preparation of this paper.

In closing this letter, allow me to mention that Mr. Hughes has addressed a communication to the French Academy of Sciences, in which he adds to his pirated telephone the induction coil, which I have always used in combination therewith, and which alone makes a practical instrument, thinking, perhaps, that under cover of a foreign language and before a society whose proceedings are not generally known in this country, he would gain for himself the credit of this combination. He makes no mention of this all-important factor in England, where it would be at once known, and in which country it has been patented nearly a year.—Yours truly, THOMAS A. EDISON.

Menlo Park, N.J., June 26, 1878.

PROFESSOR G. F. BARKER ON THE HUGHES MICROPHONE.

From advance sheets of July number of "The American Journal of Science and Art."

The results which have been obtained by Hughes are clearly anticipated by more than a year by those of Edison. In January, 1877, while engaged in perfecting an articulating telephone, Edison made use of the fact discovered by him in 1873, that semi-conductors have the peculiar property of varying their resistance with pressure. To the centre of a diaphragm was attached a spring faced with platinum, in front of which and moveable by an adjusting screw, was a small cylinder of graphite. This arrangement gave great volume of sound, but its articulation was poor. After extensive experimenting, using the graphite mixed with various substances, lead peroxide, copper iodide, pulverised gas retort carbon, manganese peroxide, amorphous phosphorus, finely-divided metals, many sulphides, tufts of silk fibre coated with metals by chemical means and pressed into discs, &c., he was led to adopt a disc made of the lampblack from petroleum smoke, and to use it in the primary circuit of a small induction coil. This constitutes the carbon telephone, which, certainly for long circuits, is the loudest transmitter known. * * * It would seem sufficiently evident that the phenomena of Hughes and Edison alike are due to the varying resistance of an electrical circuit at the point or points of contact. The correctness of this explanation is proved by the increase of the effect with multiple contacts. This is accomplished by Hughes with finely-divided materials, such as metallized carbon, or metallic filings, or carbon fragments in a glass tube; and by Edison by layers of silk covered with graphite, by several cylinders of graphite placed in a row, or by increasing the surface of his carbon button. The extreme sensitiveness of the Hughes apparatus is fully equalled by that of Edison, all the phenomena described with it being readily repeated with Edison's carbon transmitter, especially if a carbon button be used which has been worked over several times so as to be in a state of minute division. The tick, the brush, the fly tramp, can all be heard with it. For purposes of practical telephony, however, this sensitiveness is a serious objection, and was overcome by Edison only after long experimenting. It is mainly a matter of adjustment of the contact pressure, as well in the carbon telephone as the microphone, the apparatus being the more sensitive the less the pressure. Moreover, the fact that Hughes transmits speech without the use of a diaphragm does not affect the question. Edison months ago replaced the vibrating diaphragm of his telephone by a plate of metal rigidly attached to the carbon, and serving to increase the loudness by increasing the surface on which the sound acts. This, however, is not at all necessary. It is easy to talk with the carbon transmitter of Edison by projecting the sound waves directly against the carbon itself, as in the microphone. Finally, Edison has utilised the varying resistance of carbon contacts by pressure, in the construction of an apparatus by which minute differences of pressure may be measured, and has applied it to the construction of a thermometer, barometer, and hygrometer of extraordinary delicacy, and to the production of a rheostat of great simplicity.

THE MICROPHONE BECOME A TELEPHONE WITHOUT THE AID OF ELECTRO-MAGNETISM.*

In several articles which I have published on the telephone I have said that the theory which is usually put forward with regard to this apparatus is far from satisfying serious minds, and I showed that all the phenomena which have been exhibited by this instrument could not be explained by the single hypothesis of a vibration of the diaphragm serving as an armature to the magnetical system. I have shown that in the effects produced it is necessary to take into account a particular kind of vibration discovered by M. Page in 1837, and studied by M. de la Rive in 1846, which alone can explain the transmission of the word in the telephones with diaphrams, and whose origin could be but the result of molecular action. M. Luvini has lately made experiments which show the truth of this deduction, and at the same time he has completed the explanation by allowing that there is a reaction of the helix of the electro-magnet upon the magnet. But here we have fresh experiences from England, and

* *L'Electricité.*

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which show that not only is there no need to reproduce a word by a telephonic diaphram, as M. Navez so strenuously asserts, but that it can be made to pass by means of the electro-magnetical system, which brings us to an altogether new order of phenomena, and which, again, probably may be referred to that order which produces the deep vibrations in an iron wire traversed by an interrupted current.

Messrs. Hughes, Blyth, and Courtenay, inform us, in fact, that a microphone, suitably placed, talks distinctly, although less loudly than the telephone, and that the ordinary microphone can also repeat the sounds transmitted by another apparatus of the same kind.

I have ascertained the truth of this latter fact by means of the small model of a microphone made by Messrs. Chardin and Berjot, and I have been able to hear the vibrations, and in a small degree the sounds of a small musical box placed upon the microphone transmitter. To obtain this result it sufficed for me to put my ear close to the board upon which the microphone was mounted, whilst but one Leclanché battery of four elements was needed.

But I remarked that it was mainly the vibrations set up on the support itself of the apparatus which were thus perceptible; the grating which took place on the support of the microphone being also perfectly reproduced, and I could not admit that this reproduction could be the result of a mechanical transmission of the vibrations, for, when I broke the circuit, or when I withdrew the battery, no noise was perceptible.

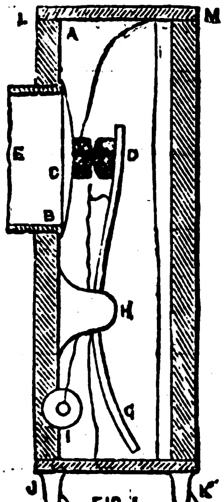

FIG. 1

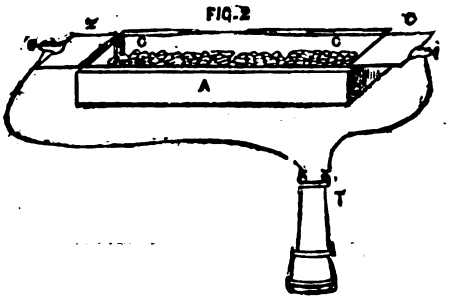

FIG. 2

We have, indeed, the mercury telephone of M. A. Breguet which contains no electro-magnetic organism, and which emits sounds by means of the oscillation of the column of mercury under the influence of electrical fluctuations; but, in the apparatus of which we are speaking, the results are far more startling, for the vibration intended to produce them can only result from the variation in intensity of a current transmitted by means of bad contacts.

Is this action to be attributed to the repulsion set up between the contiguous elements of the same current? Or should we imagine, with M. Hughes, that the electric current itself is but a molecular vibration? Is the action which is called into play in this phenomenon the same as that which furnishes the sounds in a wire traversed by a current, and which M. de la Rive has so thoroughly studied in his memoir presented to the Académie in 1846? It would be unwise to venture an opinion in the present state of the question; the fact always exists that one cannot attribute it, as I have said, to a mechanical transmission of the vibrations. It is true that, when Mr. Blyth for the first time made known these results, he met, even in England, with plenty of unbelievers, and I must say for myself that the experiments which I tried to verify them were not of a nature to convince me, for they gave only negative results; but now that the fact is well known, thanks to M. Hughes, who, from his point of view, had previously studied the question by means of his apparatus, it is probable that the results made known by M. Blyth will be verified by experiments made under favourable conditions.

The form of microphone which appears to be the best for reproducing speech is, up to the present time, that which is depicted in Fig. 1.

In a vertical board, A I, of the same size as that of an ordinary microphone, an opening is made, sufficiently large to receive the tube E of an ordinary string telephone, taking care that the parchment membrane, A B, is level with the surface of the board on the side on which the microphone is placed. In the centre of this membrane is a piece of metallised deal carbon C, placed in connection with the circuit of the battery at K, and against this piece of carbon is placed, under very light pressure, another piece of the same material D, fitted at its upper extremity with a vertical lever, pivoted upon two points in the middle H.

This lever is placed in the circuit at J, and, by means of a very fine tension screw, the pressure exerted at the point of contact of the two pieces of carbon can be rendered as small as desired. The whole is enclosed in a box L M J K, which only allows the tube E to pass outside. In this way the word can be transmitted and heard under the influence of a relatively small battery (six or seven elements of a Leclanché); but it is always far less marked than with the Bell telephone.

Messrs. Chardin and Berjot constructed this apparatus in the same way as M. Hughes' microphonic speaker, which must be used for these experiments.

In the experiments of M. Blyth, the microphone was formed of large pieces of carbon which had escaped combustion, called in England cinders, and this carbon filled a wooden box five inches by nine, furnished with two tin electrodes. A battery of two Grove elements, connected with two apparatuses of this kind, could transmit and receive.

After taking one of these microphones and connecting it with a telephone, having submerged the carbon in water, M. Blyth could disregard the battery, the microphone itself constituting the battery. In this way he could readily transmit words, and he could prove that the sounds transmitted were due to the carbon, for when it was removed nothing was heard.

As I have already said, I have not been able to hear any sound under the conditions mentioned above. It is true that I have used "coal cinders," which, as indicated in M. Blyth's memoir, were not in all probability under good conditions; but, by placing on the two opposite sides of a small flat box, ten centimetres by six, two electrodes, zinc and copper, as is shown in Z C, fig. 2, and filling up the interval with large pieces of retort carbon C C, near enough to one another to form a nearly continuous bed, I have been able, by immersing the carbon in water, to obtain without a battery a very good telephone transmitter. Every sound and even word was exactly reproduced, and there was the advantage of not hearing those disagreeable jarrings which sometimes accompany the sounds created by the microphone.

Lastly, M. Cauderay, of Lausanne, has observed results of the same kind by placing a microphone in a telephonic circuit of 500 metres long and connected to earth.

Upon placing a watch on the microphone, one could hear the ticking in the telephone, without its being necessary to employ a battery. In this case, the electric current was developed by the earth plates which, with the sun, made up an earth couple sufficient to work the telephone.

I said a short time ago that the effects produced in a microphone used as a receiver were difficult to explain, and that they probably had some attributes in common with those which are produced in an iron wire traversed by a frequently intercepted current; but here are other phenomena of the same kind which evidently must be of the same stock as those which form the subject of this article.

For instance, M. des Portes, who, in a complimentary memoir which he sent me, has recognised that if one places a magnetic bar in a telephonic circuit, and the two ends of the circuit wire which complete the contacts are helically arranged outside their polar extremities, the blows struck on the magnet with an iron rod are perceptible in the telephone, but with this condition, nevertheless, that one of the poles of this magnet is connected with an earth plate. On the other hand, I acknowledge that the vibrations caused on one of the wires which connect two telephones are perceptible in the telephones, from whatever part of the circuit the vibrations may be produced. The sounds first produced are in reality very weak, but they become clearly distinguishable, and acquire a greater intensity when the vibration is produced on the terminals which connect the telephone. All these sounds, however, cannot evidently be the result of a mechanical transmission of vibrations, for when the circuit is broken they cannot be perceived. After this experience one might believe that certain noises which one notices in experiments with the telephone on telegraph lines might easily arise from the friction of the wires on the supports, a friction which gives rise to those sounds, often so intense, which one hears on certain lines of telegraph.

To conclude, all these experiments show that, as M. Navez says, the theory of the telephone is far from complete, and that the old theories of acoustics are now insufficient. It is evidently necessary to take into account the molecular vibrations, which M. de la Rive talked of as early as 1846, and, when people are more familiar with this kind of phenomena, they will be able to explain results which, at present, must appear incomprehensible.

TH. DU MONCEL.

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RECENT PATENT.

4349. Automatically Signalling Set on Railway Lines, *A. Wrigley*. —*Dated 20th November*, 1877. 10*d*.

This invention relates, firstly, to a method of indicating to coming trains the time that has elapsed since the preceding train passed the signal; secondly, to a method of automatically signalling from one signal to another, so as to indicate whether a train has passed a certain point or signal in front. The apparatus used to carry out the first part of this invention consists of certain clockwork or mechanism, being a combined mechanical and electric clock, as hereinafter described, arranged to actuate a disc, upon which is displayed—by being figured, printed, mounted, or otherwise delineated or cut out—certain observable figures or letters indicating periods of time clearly visible. The disc upon which the indications of time are mounted is provided with a small drum, upon which is wound a weighted chain or cord. The disc and drum are carried by and run loose on their axle, so that the weighted chain causes the disc in its normal state to indicate zero by displaying blank or a cypher, that being when at rest the upper mounted or otherwise delineated figure, letter, or indication. On the side opposite to the drum the disc is provided with teeth or projections, which gear into teeth or projections on a clutch sliding on a keyway. This sliding clutch is actuated by mechanical means or by electricity by the action of the passing train. The sliding clutch is carried on and works on the same axis as the motion wheel of a clock, which clock is arranged as a mechanical clock driven by weights or a spring, or as an electric clock driven by the action of a pendulum which is kept in motion by an electric magnet, the electric current effecting this by means of an armature on the pendulum, the end of the pendulum being provided with a spring contact-maker. The apparatus used to carry out the second part of this invention consists of an electric engine, being a magnet wheel provided with a series of armatures, and operated or rotated by a series of electro-magnets. The axis of the magnet wheel is provided with a pinion, which drives a spur wheel, on the axis of which is mounted a second spur wheel, with the teeth on a portion of its circumference cut away. This last spur wheel operates a toothed quadrant, on the axis of which is mounted a door or semaphore of any suitable pattern, a convenient form being a double door opening in the centre, and connected by means of two levers and a suitable connecting rod.

THE GLOBE TELEGRAPH AND TRUST COMPANY (LIMITED.)

FIFTH ORDINARY GENERAL MEETING, 30TH JULY, 1878.

ABSTRACT OF THE REPORT OF THE DIRECTORS.

The balance sheet and accounts for the year ending 18th July, 1878, with statement of the stocks and shares held by the Company at that date, are herewith submitted. The net revenue of the company for the year, after deduction of expenses, amounts to 154,404*l*. 10*s*. 6*d*., which, with the balance brought forward, makes a total of 154,824*l*. 10*s*. 8*d*. From this amount there has been distributed in interim dividends the sum of 115,399*l*. 4*s*., and the directors have written 500*l*. off the preliminary expenses account. The directors now recommend payment of a final dividend for the year of 3*s*. per share on the preference shares, and of 2*s*. per share on the ordinary shares, making, with the former distributions, a total dividend for the year of 6 per cent. upon the preference and 4 per cent. upon the ordinary shares, leaving a balance of 425*l*. 6*s*. 8*d*. to be carried forward. In last year's report the directors referred to the advantage likely to arise in increased revenue to this company by the cessation of hostile competition between the Atlantic Telegraph Companies, and their anticipations have so far been realised. The market value of the stocks and shares held by the company shows an improvement as against this time last year of about 6 per cent.

TELEGRAPH SHARE LIST.

Amount of Issue.	Amount of Share.	Paid on Share.	Company.	Reserve as per last Report.	Dividends calculated at rate per cent. per annum. 1875. %	1875. %	1876. %	1876. %	1877. %	1877. %	When Payable.	Prices. 1875. Highest.	1875. Lowest.	1876. Highest.	1876. Lowest.	1877. Highest.	1877. Lowest.
€3,254,580	Stock	100	PAnglo-American	Deferred receiving no dividend until 6 per cent. has been paid to Preferred.		year.	5	4†	3	5	† Div. 5 % per ann. for quarter ending Dec. 31, 1876, 2% for quarter ending Mar. 31, 4 % for quarters ending June 30 and Sept. 30, 6 % for quarter ending Dec. 31, 1877, and 4 % for quarter ending March 31, 1878.	75½	51½	68½	53	62¼	52
1,872,710	Stock	100	Do. Preferred B		—	—	10	2	6	6		Crtd	1876.	93	75	88½	79
1,872,710	Stock	100	Do. Deferred A		—	—	Nil.	6	Nil.	4		Crtd	1876.	44	29	38	25½
1,300,000	10	All	Brazilian Submarine	120,000	5	5	5	5	5	5	Quarterly.	7¾	6	7¼	5¾	6¼	5⅞
160,000	10	All	Cuba (Limited)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60,000	10	All	Do. 10 per cent. Preference	—	—	—	—	—	—	—	—	—	—	—	—	—	—
116,379	10	9	Direct Spanish (Limited)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
58,430	10	All	Do. 10 per cent. Preference	—	—	—	—	—	—	—	—	—	—	—	—	—	—
65,000	20	All	Direct United States	Nil.	—	Nil.	Nil.	Nil.	Nil.	5	Quarterly.	13	7	11½	6¼	13⅜	9½
369,700	10	All	Eastern (Limited)	110,000	5	year.	5	5	5		*a*Jany., April, *July*, Oct.	8	6⅝	7⅛	5	8¼	6⅝
232,000	100	All	Eastern 6 per cent. Debentures	—	—	—	—	—	—	—	—	—	—	—	—	—	—
200,000	100	All	Do. 5 per cent. Debentures	—	—	—	—	—	—	—	—	—	—	—	—	—	—
700,000	10	All	Do. 6 per cent. Preference	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,997,500	10	All	Eastn. Exten. Australasia & China	125,404	5½	year.	5	year.	5	year.	*a*Jany., *April*, July, Oct.	8¼	7	7½	5⅛	8	6⅝
320,000	100	All	Eastn. Exten. 6 p.c. Deben. (1875)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
192,680	10	All	German Un. Tl. and Tst.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,500,000	10	All	Globe Telegraph and Trust	Nil.	5	7 4-5	4½	7 5-6	3⅜	7 6-7	*b*Jany., April, *July*, Oct.	6¾	5⅛	5⅞	4¼	5¼	4¼
1,500,000	10	All	Do. 6 per cent. Preference		6	6	6	6	6	6	Jany., April, July, Oct.	10½	9¾	10⅛	9¼	10½	9¼
150,000	10	All	Great Northern	85,543	5⅝	year.	6⅜	year.	6⅜	year.	5 % intrm. Jan. 1, July 1. Final Dividend April.	11½	7½	9¾	7	8	7
			Shares to Bearer, or can be Regstrd.														
—	25	All	Indo-European	—	—	—	—	—	—	—	—	—	—	—	—	—	—
120,000	10	All	Mediterranean Extension (Lmtd.)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
32,000	10	All	Do. 8 per cent. Preference	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	18	All	Reuter's (Limited)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
65,000	10	All	West India and Panama	16,000	Nil.	Nil.	Nil.	Nil.	1	1	‡ Converted from a 10 %	4¾	1⅝	2½	⅝	3⅝	1½
34,563	10	All	Do. 6 per cent. Preference		7/6ac	year.	10/ac	year.	6‡	6	into a 6 % 1st Preference.	12	9	11	7	11	7½
67,500	20	All	Western and Brazilian	7,793	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Half-yearly.	18¾	9½	10⅝	4½	5¾	4½
$1,500,000	$1000	All	Western Union Telegraph 7 per cent. First Mortgage Bonds	—	7	7	7	7	7	7	May, November.	108	102½	109½	105	113	106
£1,030,000	200	All	Do. 6 per cent. Sterling Bonds	Redeeemable by annual drawings at par.	6	6	6	6	6	6	March 1, September 1.	93	86	98	89	101	94

a Year ends March 31st. Interim Dividend of 5 per cent. Final dividend in July. *b* Year ends July 18th. Final dividend in July.

Companies.	Closing Prices 24th July.		Business Done Week Ending 24th July. Highest.	Lowest.
Anglo-American	63½,	3	63½ ex div.	62½ ex div.
Do. B.	91½,	2	92 ex div.	91½ ex div.
Do. A.	36,	½	36½	36½
Brazilian	6 15-16,	7 1-16	7½	7 1-16
Cuba	9½,	½	9½	9½
Do. Ten per Cent. Preference	16,	17	—	—
Direct Spanish	—	—	—	—
Do. Ten per Cent. Preference	9½	10	—	—
Direct United States	14½,	½	14½	14½
Eastern	7½,	½	7 15-16 ex div.	7½ ex div.
Do. Six per Cent. Debenture	108,	10	—	—
Do. Five per Cent. do.	103½,	4½	—	—
Do. Six per Cent. Preference	11½,	½	11½ ex div.	11½ ex div.
Eastern Extension	7½,	½	7 15-16	7½
Do. Six per Cent. Debentures	110,	12	110½	110½
German Union	8½,	9	—	—
Globe Telegraph and Trust	5½,	½	5 11-10	5 9-16
Do. Six per Cent. Preference	11,	½	11½	11
Great Northern	8½,	½	9	8½
Indo-European	20,	½	20½	20
Mediterranean Extension	2½,	3	3½	3½
Do. Eight per Cent. Preference	9½,	½	—	—
Reuter's	10,	11	—	—
West India and Panama	2 7-16,	9-16	2½	2½
Do. Six per Cent. Preference	8½,	½	8 15-16	8 10-16
Western and Brazilian	4½,	½	—	—
West. Union 7 p. Cent. 1st Mortgage	117,	19	118½	118½
Do. Six per Cent. Sterling	102,	4	103½	102½

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NOTES.

Companhia Telegraphica Platino-Braziliera.—The directors state that upon receipt of a report from Messrs. Deloitte and Co. showing the exact position of the company's affairs, they hope to be in a position to recommend a dividend. It is proposed to appoint a committee to decide upon a scheme for the alteration of the constitution of the company.

Gas Lighting by Electricity.—The system of lighting the public lamps by electricity on the plan invented by Mr. Lane Fox, recently put to the test in Pall-mall, does not seem to have met with the success that was at first claimed for it. At the last meeting of the St. James's Vestry it was officially reported that the system had proved an entire failure, and it was decided to request Mr. Fox to remove the apparatus at once.

Electrotypes of the Brains.—Among the novelties to be seen at the Paris Exhibition is a series of specimens of plated human brains sent by Dr. Ore, the ingenious Professor of Physiology at the Bordeaux School of Medicine. Dr. Ore has applied galvano-plasty for purposes of preservation to the brains of men and animals, and has obtained very remarkable results, the external surface presenting the hard brilliant surface of a metal, while the inner substance assumes the consistency of mastic, and is quite unalterable.

The Cuba Cable Restored.—The No. 3 Cable of the International Ocean Telegraph Company between Key West and Havana has been repaired, and telegraphic communication restored. The final splice was completed and the cable passed overboard from the Cable Steamship *Prof. Morse*, at 5:30 a.m., July 7. The *Prof. Morse* is now engaged in recovering and repairing the No. 2 Cable of the company, and it is expected that within a short time there will be two cables in good order for the transmission of messages between the United States and Cuba.

Torpedo Telegraph Posts.—This term is applied by our contemporary, *l'Electricité*, to certain posts in Australia, which, we are informed, are "by an arrangement of supplementary currents," caused to communicate a severe shock to anyone meddling with them. They resemble, in fact, the torpedo-woman exhibited at fairs. The unexpected punishment, attributed to supernatural power, which fell upon certain natives in the vicinity of McDonald Peak, when they attempted to cut the wire, has had the effect of deterring other tribes from in any way damaging the line, of which the total length is 3,160 kilomètres (about 2,100 miles).

Magnetic Observatory.—A new magnetic observatory has been opened at Pavlovsk in connection with the Central Physical Observatory of St. Petersburg. It covers about eight hectares of surface, and the situation is favourable. The establishment comprises three principal scientific buildings, the main building of stone and surmounted by a tower for meteorological observations; a double-arched structure in stone covered with earth for observations in magnetic variation; and a wooden pavilion, without a particle of iron, for absolute magnetic measurement and for determinations of time. All the structures are roofed with bituminised paper.

The Effect of Temperature upon Atmospheric Electricity.—H. Goldmark, of Harvard College, contributes a short paper on this subject to the July number of the American *Journal of Science and Arts*. To obtain the potential of the air he used the water-dropping apparatus of Thomson. To measure the potential a quadrant-electrometer was employed, which was charged sometimes by a Holtz machine and sometimes by the Ruhmkorff coil. The deflections were observed by means of a telescope at the opposite end of the room to the instrument, in order to avoid any influence which the observer's body might have upon the instrument or wires. The conclusions arrived at are:—1. That even a very considerable change of temperature does not have *any great* or *marked* effect upon the electric potential of the air. 2. That, however, a rise in temperature does produce a *slight but constant* increase in the potential.

Silvering and Gilding Zinc.—A direct silvering of zinc, according to Ebermayer, is not practicable, for although the the zinc covers itself speedily and nicely with silver as well as with gold, yet this coating becomes dull and unseemly after a short time. The cause of this may be that the covering is too thin to perfectly cover the zinc. There is no other means left, therefore, but plating the metal first with brass or copper. It not being sufficient, however, to merely cover the zinc by simple immersion, it is necessary to produce a good, durable precipitate, which may be accomplished by using the galvanic battery and a solution containing cyanide of potassium. A process has of late been published in Germany to copper-plate zinc articles by simply suspending them on zinc wires in a solution of blue vitriol and caustic potash, which to prevent a precipitate being thrown down, is mixed with tartaric acid or glycerine. Ebermayer further remarks that all articles made of sheet zinc are better adapted for plating with brass than castings, because the latter, if not most carefully handled, are liable to be disfigured with black spots.—*Engineer.*

Edison's Phonometer.—It is admitted that there is power in the human voice, but hitherto this power has been applied indirectly to produce mechanical results. Mr. Edison in his telephone and phonograph experiments discovered that the vibrations of the vocal cords were capable of producing considerable dynamic effect. Acting on this hint he began experiments on a phonometer, or instrument for measuring the mechanical force of sound waves produced by the human voice. In the course of these experiments he constructed the machine, which exhibits the dynamic force of the voice. The machine has a diaphragm and mouth-piece similar to a phonograph. A spring which is secured to the bed-piece rests on a piece of rubber tubing placed against the diaphragm. This spring carries a pawl that acts on a ratchet or roughened wheel on the fly wheel shaft. A sound made in the mouth-piece creates vibrations in the diaphragm, which are sufficient to propel the fly wheel with considerable velocity. It requires a surprising amount of pressure on the fly wheel shaft to stop the machine, while a continuous sound is made in the mouth-piece. Mr. Edison says he will have no difficulty in making the machine bore a hole through a board; but we consider such an application of the machine of very little utility, as we are familiar with voices that can accomplish the feat without the mechanical appliance.—*Scientific American.*

Dangers that Beset Submarine Cables.—Every one who has at all studied oceanic telegraphy perfectly understands the dangers to which the shore ends of communicating wires are exposed from the action of currents, the anchors of ships, &c. But the general idea prevailed that once the cable was laid in the gloomy depths of the ocean, it was in safety. Such, however, is not the case, for the inhabitants of those regions seem to resent the intrusion. In many cases, owing to the inequalities of the bottom of the sea, the wires cannot rest wholly on the bed, but in some

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places hang in festoons. Then they are liable to accidents from the larger denizens of the sea, among which we may particularly mention the sun-fish (*Orthagoriscus*). That peculiar but little known animal is nearly circular, of a brilliant silvery white, and at night emits a powerful phosphorescent light, whence its name probably arose. When swimming it turns round like a wheel, and moves with great rapidity. It grows to an enormous size, often attaining four feet in diameter, and some of them are said even to reach eight feet. Specimens have been caught weighing 500 pounds. It is found in all seas from the Arctic to the Antarctic Circle. Where the tail is in ordinary fishes, this curious creature has a sort of flattening in its circular shape, from which bony spines project. Not long since an interruption occurred in a cable, and on examination it was found that it had been penetrated by one of the caudal spines of the sunfish. Even when the wire lies quiet at the bottom it is not safe, for a species of marine weevil attacks the gutta-percha and gradually destroys the conductivity. But the most curious instance of damage inflicted on a cable is that which lately befel the one from Portugal to Brazil. A fault having been found, the tests were applied, and the precise spot indicated. The wire was fished up and was discovered to be broken. In one of the ends was entangled a large whale. The monster was covered with parasites, and in attempting to free itself from its tormentors, had broken the cable, and then managed so to twist itself in the coils of one end that it was held fast as a prisoner, and, not being able to rise to the surface for air, was drowned.—*Galignani's Messenger.*

Telephonic Relay.—Prof. Rood, in *Amer. Jnl. of Science and Arts*, says:—"After reading the account of the experiments of Mr. Hughes, which may be regarded as an extension of the work of Edison, it occurred to me that the peculiar property of carbon upon which they depend might be utilized in the construction of a telephone relay. I accordingly arranged three pieces of carbon in the form of an H, attaching the two outside pieces to the diaphragm of an ordinary telephone; this, with a battery, was destined to act as relay and re-transmitter. The first circuit included, then, a common telephone as sender, and the coil of the relay; the second included battery, vibrating carbon, and a common telephone used as a receiver. It was found that the vibrations of the pivots of the central piece of carbon were, indeed, able to modulate an electric current, so as to reproduce with somewhat diminished intensity sounds uttered in the sending telephone. Eight small vibrating carbons were now substituted for the single piece, and the reproduction was effected without loss of intensity or distinctness. The battery used with the relay consisted of eight small cells of zinc and carbon, placed in diluted sulphuric acid only. For a relay to be efficient it is, of course, necessary that it should increase the loudness of the sounds, so as to allow for electrical re-transmission to a more distant station. This can probably be effected—1st, by making the telephone relay of such dimensions that six or eight carbons can be placed approximately over the centre of the iron diaphragm; and, 2nd, by using simultaneously several of these pieces of apparatus in the same circuit. An arrangement like Hughes's microphone was also employed as sending instrument; an inverted coverless cigar box was used, in which I placed three vibrating carbons instead of a single one. The multiplication of the carbons is due to a suggestion of Dr. W. Gibbs, who at the time proposed various forms of sending apparatus, all including the principle of multiple vibrating points or surfaces of contact. This simple apparatus was very sensitive, and reproduced with fidelity conversation in a low tone at a distance of more than thirty-five feet from the box; its performance suggested to me the multiplication of the carbons on the relay. To the above I may add that when the electrical current used with the carbons is too powerful, a hissing, cracking sound is produced, which is from time to time varied by the introducion of a pure musical note, which often runs through considerable variation in pitch. This voltaic tone may be due to the repulsion exerted by the electrical current on itself, causing one of the carbon points to rise and fall with regularity in a manner analogous to the motion of the Trevelyan rocker, or it may be caused by rapid changes of temperature, and hence in volume of the contact-surfaces. With fourteen small cups it occurred quite frequently."

On the Electrical Aftercurrents of Transversely Magnetized Iron Rods.—By Prof. H. Streintz.—The experiments referred to in this paper were carried out by the author in conjunction with Dr. F. Streintz. The phenomenon was discovered by Villari, that in a rod of iron or steel through which a galvanic current has passed, when agitated after the interruption of this current, a galvanic current is again generated the same in direction as that originally conducted through the rod. He subsequently investigated some properties of these aftercurrents, and gave an explanation of the phenomenon:—namely, that the rod is transversely magnetised by the current; and if we employ the notion of molecular magnets, these arrange themselves in concentric circles around the axis of the rod. Now, if the rod be agitated after the interruption of the current, the molecular magnets obey the direction-force which tends to mingle them again irregularly. We can here avail ourselves of the representation of the molecular magnets returning to the positions which they had before the action of the current. Now, in this return they generate in the rod an induction-current, to which Villari gives the name of "agitation-current," but which may with equal suitableness be designated as an aftercurrent. Afterwards H. Herwig studied the properties of transverse magnetism on iron tubes. The author now shows that in a very simple manner the quantity of the magnetising force can be calculated which is exerted upon the molecular magnets by the current originally conducted through the rod. Starting from Biot and Savart's theorem, that a rectilineal current of infinite length acts upon a pole of a magnet with a force inversely proportional to the perpendicular distance of the pole from the conductor, the problem is reduced to one of the plane; so that we have to calculate the action of a circular surface with uniform mass (the rods investigated had a circular cross section) upon a mass-point situated in the surface. In accordance with the laws of force previously stated, however, a circular line with uniform mass exerts no action on a point situated in the enclosed surface, while it acts on an external point in the same plane as if the mass of the circle were collected in the centre. Now by this the calculation becomes very simple, and we obtain, as the force which is exerted upon a magnetic pole situated at the distance r from the axis, $p = \frac{kr}{a^2}$, in which k is a constant, and a the semidiameter of the rod. The total moment upon all the molecular magnets contained in the rod is then $R = Kla$, where K, again, is a constant, and l denotes the length of the rod. The author has also investigated by experiment the properties of the aftercurrents; and in so doing he found some confirmed which could be foreseen from the theoretical developments, and also discovered various other properties, some of them, indeed, very striking, which could not have been determined *à priori*.—*Kaiserliche Akademie Wissenschaften in Wien, math.-naturw.*

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THE ABSOLUTE UNIT OF ELECTRICAL RESISTANCE.

BY PROFESSOR H. A. ROWLAND.

[CONTINUED FROM P. 101.]

The Circle.—The circle whose constant we have called G″, and which was around the galvanometer whose constant was G, was a large wooden one, containing a single coil of No. 22 wire. To prevent warping, it was laid up out of small pieces of wood with the grain in the direction of the circumference, and was carefully turned with a minute groove near one edge in which the wire could just lie. It was about 5 cm. broad, 1·8 thick, and 82·7 cm. diameter. As the room had no fire in it, the circle remained perfect throughout the experiment. The wire was straightened by stretching, and measured before placing on the circle, which last was done with great care to prevent stretching; after the experiment it was measured, and found exact to $\frac{1}{10}$mm. The circle was adjusted parallel and concentric with the coils of the galvanometer, but at a distance of 1·1cm. to one side, in order to allow the glass tube with the suspending fibre to pass. The length of wire was 259·58cm., which gives a mean radius of 41·31344 cm. These data give G″= ·151925. Preliminary results were also obtained by use of another circle.

Chronometer.—To obtain the time of vibration, a marine chronometer, giving mean solar time, was used. The rate was only half-a-second per day.

Wheatstone Bridge.—To compare the resistance of the circuit with the arbitrary German silver standard, a bridge, on Jenkin's plan, made by Elliott, of London, was used. A Thomson galvanometer, with a single battery cell, gave the means of accurately adjusting the resistance, one division of the scale representing one part in fifty thousand.

Thermometers.—Accurate thermometers graduated to half degrees were used for finding the temperature of the standard.

The Arbitrary Standard.—This was made of about seventy feet of German silver wire, mounted in the same way as the British Association standard. Immediately after use, two copies, one in German silver and the other in platinum silver alloy, were made. It had a resistance of about 35 ohms. The temperature was taken as 17° C.

To obtain the accurate resistance of this standard in ohms, I had two standards of 10 ohms and one 1,100 and 1,000 ohms. The one ohm, and one of the 10 ohm standards, were made by Elliott of London, and the others by Messrs. Warden, Muirhead and Clark, of the same place. But, on careful comparison, I found that Warden, Muirhead, and Clark's 10-ohm standard was 1·00171 times that of Messrs. Elliott Brothers. On stating these facts to the two firms, I met no response from the first firm, but the second kindly undertook to make me a standard which should be true by the standards in charge of Professor Maxwell, of Cambridge. At present I give the result of the comparison with these standards, as well as some others, and also with a set of resistance coils by Messrs. Elliott Brothers.

Commutators. — No commutators except those having mercury connections were used, and those in the circuit whose resistance was determined were so constructed as to offer no appreciable resistance. The commutator by which the main current was reversed could be operated in a fraction of a second, so as to cause no delay in the reversal.

Connecting Wires.—These were of No. 22 or No. 16 wire, and were all carefully twisted together. The insulation was tested and found to be excellent.

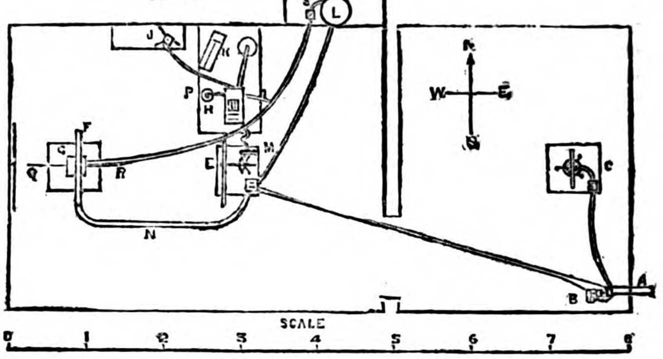
Inductor for Damping.—This has already been described in my first paper on "Magnetic Permeability," and merely consisted of a small horse-shoe magnet with a sliding coil, which was introduced into the secondary circuit. By moving it back and forth, the induced current could be used to stop the vibrations of the needle, and make it stationary at the zero point. This is necessary in the method where the first throw of the galvanometer needle constitutes the observation; but, in the method of recoil, it is not necessary to use it very often. I prefer the method of the first throw, as a general rule, but I have used both methods.

This method of damping will be found much more efficient than that of the damping magnet, as taught by Weber; and after practice a single movement will often bring the needle exactly to rest at the zero point.

Arrangement of Apparatus.—Two rooms on the ground floor of a small building near the University were set aside for the experiment, making a space 8 m. long by 3·7 m. wide. The plan of the arrangement is seen at Fig. 1. The current from the battery, in the University, entered at A, the battery being eighteen one-gallon cells of a chromate battery, arranged two abreast, and eight for tension. The resistance of the circuit was about 20 ohms, and of the whole battery about ½ ohm, thus insuring a reasonably constant current. At B some resistance could be inserted by withdrawing plugs so as to vary the current. At C is the tangent galvanometer with commutator on a brick pier. The nearness of the commutator produces no error, seeing that we only wish to determine the ratio of two currents. The effect of currents in the commutator was, however, vanishingly small in any case. At D is the principal commutator which reversed the current in the induction coils, L, or in the circle, F, when it was in the circuit. The secondary circuit included the induction coil L, the damping inductor M, and the galvanometer G. At H was the Jenkin's bridge, with standard at P, in a beaker of water, and a Thomson galvanometer at J K. The secondary circuit could be joined to the bridge by raising a U-shaped piece of wire out of the mercury cups. The telescope and scale, E, were on a heavy wooden table, and the two galvanometers on brick piers with marble tops. A row of gas-burners at Q illuminated the silvered scale in the most perfect manner.

Adjustments and Tests.—The circle, F, must be parallel to coils of galvanometer, G. The circle and coils of galvanometer were first adjusted with their planes vertical, and then adjusted in azimuth by measurement from the end of the bar, R, to the sides of the circle, F. The adjustment was always within 30′, which would only cause an error of one part in 25,000°. The needle must hang in the magnetic meridian by a fibre without tension, and the coils must be parallel to it. These adjustments were carefully made; but, as has been shown, the error from this source is compensated. The needle must hang in the centre of the galvanometer coils and on the axis of the circle. The error from this source is vanishingly small. The scale must be perpendicular to the line joining the zero point and the galvanometer needle. All errors from this source are partially or entirely compensated by the method of experiment. The induction coils, L, must be horizonal, and at the same level as the two galvanometers, so as not to produce any magnetic action on them. The error from this source is exactly compensated by this method of experiment, but could never amount to more than 1 part in 2,000. The tangent galvanometer should have the plane of its coils in the magnetic meridian, but all errors are compensated. The connecting wires must be so twisted together and arranged as to produce no magnetic action; but tests were made in all cases where the error was not compensated, and found to be practically zero. The insulation of all coils, wires, and commutators was carefully tested.

FIG. 1.



Method of Experiment.—As has been stated before, the method generally used was that of the first throw of the needle, though the method of recoil was also used. For the successful use of the first method a quickly vibrating needle and the damping inductor are indispensable, seeing that with a slow moving needle we can never be certain of its being at rest. By this method it is not necessary to have the needle at rest at the zero point, but, if it vibrates in an arc of only a millimeter or two, we have only to wait till it comes to rest at its point of greatest elongation on either side of the zero point, and then reverse the commutator. The error by this method is in the direction of making the throw greater in proportion of the cosine of the phase to unity. The smallest throw used was 100 mm. Hence, if the needle vibrated through a total arc of 2 mm., the error would be 1 in 17,000. In reality, the needle was always brought to rest much more nearly than this. The method of recoil was used once with the needle vibrating in 7·8 seconds, but the time of vibration was too short, and another needle was constructed vibrating in 11·5 seconds, which was a sufficiently long period to be used successfully after practice. There seems to be no error introduced by the time taken to reverse the commutator in the method of recoil, seeing that the breaking of the current stops the needle, and the making starts it in the opposite direction. As the time was only a fraction of a second, the error is minute in any case. While the current is broken in the reversal the battery may recuperate a little, and there is also some action from the extra current, but there seems to be no doubt that long before the four

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or six seconds which the needle takes to reach its greatest elongation everything has again settled to its normal condition, and the current resumes its original strength. Hence the error from these sources may be considered as vanishingly small. Some experiments were made by simply breaking the current, and they gave the same result as by reversal. The following is the order of observations corresponding to each experiment:—

1st. The time of vibration of needle was observed.

2nd. The current was passed around the circle, F, so as to observe β and a. Simultaneous readings were taken at the two galvanometers. The commutator at the tangent galvanometer was then reversed, and readings again taken. After that the commutator to the circle was reversed and the operation repeated. This gave four readings for the circle and eight for the tangent galvanometer, as both ends of the needle were read. In some cases these were increased to six and twelve respectively. This operation was repeated three times with currents of different strengths, constituting three observations, each of a and β. To eliminate any action due to the induction coils, they were sometimes connected in one way and sometimes in the opposite way.

3rd. The resistance of the circuit was adjusted equal to the arbitrary standard.

4th. The circle, F, was thrown out the circuit and the observations of θ and δ begun. Two throws, δ, one on either side of zero, were observed and one reading of θ taken. The commutators at s and C were then reversed, and the operation repeated. This whole operation was then repeated with currents of three different strengths. The position of the two induction coils was now reversed, and observations again made with the three currents. The resistance was now compared with the standard, the difference noted, and the resistance again adjusted. The observations were completed by turning the induction coils into the two other positions which they could occupy with respect to each other, followed by another comparison of resistance with standard. 5th. Observations of a and β again made as before.

6th. The time of vibration was again determined. The observations, as here explained, furnished data for three computations of the resistance of the circuit, one with each of the three currents. In each of these three computations, a was the mean of 16 readings, β of 8, or sometimes 12, θ of 16, and δ of 16. In using the method of recoil, nearly the same order was observed. The time of vibration was determined by allowing the needle to vibrate for about ten seconds, and making ten observations of transits before and after that period, During the experiment I usually observed at the telescope, and Mr. Jacques at the tangent galvanometer. The methods of obtaining the corrections require no explanation.

[TO BE CONTINUED.]

THE TELEGRAPH STATISTICS OF BELGIUM.

M. Vinchent, the Director-General of the Belgian Telegraphs, has published, under date April, 1878, his usual annual report* upon the results of the previous year's working of the Belgian system, from which we make the following extracts:—

In 1877, for the first time, the telegraphic correspondences of the kingdom were less numerous than in the preceding year, the cause being the general stagnation of business. The following table gives the *difference* in the number of messages, in the amount of receipts, and in the net profit, as compared with the year 1876:—

Service.	Messages.		Difference in Receipts		Difference in Net Profit per Message. Francs.
	Difference in Number.	Percentage.	Francs.	Percentage.	
Interior	− 9,729	·5	− 670·25	·6	nil.
International	− 13,203	1·8	−21,281·91	2·7	− ·01
Transit	+ 12,234	5·3	+28,917·21	10·17	+ ·05
Totals	− 10,608	·4	+ 870·05	·04	

The proportion per cent. of the various classes of messages will be seen by the following statement:—

	Internal. per cent.	Foreign. per cent.	Total. per cent.
Government messages...	½	1½	1
Bourse ,, ...	5¼	13¼	9¼
Commercial ,, ...	30¾	44¼	37½
Social ,, ...	62½	38	50¼
News ,, ...	1	3	2
	100	100	100

* Extract from Records of Public Works, Vol. 36.

"Urgent" telegrams, taking priority over other private messages, can be sent at double the charge for ordinary correspondence. This class of business amounted last year to only 2½ per cent. of the total traffic. The double rate is obligatory for messages to be transmitted between nine in the evening and the hour of opening the offices for the daily service in the morning. Out of 1,000 ordinary internal telegrams

772 occupied less than half-an-hour
202 ,, between 30 minutes and 1 hour
23 ,, ,, 60 ,, 1½ hours
3 ,, ,, 1½ and 2 hours

between the deposit of the message at the transmitting office and delivery at its destination. Counting every difference between the original of an internal telegram and the copy delivered, there were three errors in every thousand words transmitted, equal to one error in twenty messages. The public demanded repetitions, however, of only 20,000 telegrams, or one in every 145. Acknowledgment of the receipt of a message can be obtained for 50 centimes.

In the four great cities of Belgium a letter or post-card bearing a telegraph stamp of 25 centimes, in addition to the postage stamp, is delivered by express by means of the messengers organised for the delivery of telegrams. This service is conducted in offices connected by the tramways, the cars being also fitted with boxes to receive the communications for delivery. The success of this plan increases every month. In 1877 44,219 letters and 46,693 post-cards were so delivered; the receipts to the credit of the Telegraph Department being 22,728 francs. The time between deposit in the boxes provided and delivery varies from 19 to 29 minutes.

As regards international service the telegraphic relations between Belgium and the following States show the *decrease* denoted by the figures following them:—Holland, 1¼ per cent.; Great Britain, 5¼ per cent.; France, 6½ per cent.; Switzerland, 17½ per cent.; Russia, 12 per cent.; Turkey and Principalities, 3¾. While the messages exchanged with the following countries show the increase noted. Germany, 1 per cent.; Austro-Hungary, 23¾ per cent.; Italy, 5½ per cent.; Spain and Portugal, 20 per cent.; Asia Minor, Persia, and India, 58¼ per cent.; Egypt, Algeria, &c., 8¼ per cent.; America, 48½ per cent.

The increase in the case of Asia Minor, Persia and India, and America, is very remarkable. The transit correspondence shows an increase in but two cases. Holland and Switzerland, 12 per cent.; Holland and France, 3½ per cent.; whereas England and Germany show an increase of 8½ per cent.; Holland and Italy, 8¾ per cent.; Holland and Spain and Portugal, 14¼ per cent. While the messages between Belgium and other countries diminished nearly 2 per cent. between 1876 and 1877, the number of "telegraphic advices (*avis télégraphiques*) increased 64 per cent. and "urgent" messages 45 per cent. The former are limited to ten words, and may contain neither ciphers nor code language—the charge being 3-5ths of that for an ordinary message of twenty words. Of the European countries, England, Germany, Italy, and Switzerland, do not admit this class of correspondence.

"Urgent" international telegrams are charged three times as much as ordinary messages, and are accepted by all the States except England and Switzerland. They are shown to have increased the receipts of the Belgian lines 53,634·27f., while the telegraphic "advices," assuming each to have obviated the necessity for a message of twenty words, have caused a loss of 5,394f. 70c. The total revenue of the Telegraph Administration for the year 1877 was 2,165,243f., or only 6,094f. more than in the previous year. The receipts for wires and instruments leased amount to the insignificant sum of 3,000f. All the charges on messages, excepting those amounting to more than 500f., which may be collected in cash by certain offices, are paid by means of stamps. The "service" messages required for the working of the telegraph service amounted to only 3¾ per cent. of the total number of free messages, which were equal to nearly half of the total number of messages carried. The railways necessitated 85 per cent., and the Post Admiralty and Central Administration 11¼ of the free messages. Turning now from the messages to the means for transmitting them, we find the position of the Belgian Telegraphic system on the 31st of December, 1877, to be as follows:—

Length of lines	kilomètres	5,173
,, ,, conducting wires	,,	22,569
Extension of lines	,,	87
,, ,, conducting wires	,,	488

Offices open, 636. Instruments in use, 1,154.

Only 9·181 mètres of line are subterranean. As to apparatus the Morse is generally employed. The principal offices of some of the large towns use in addition the Hughes instrument. Dial and letter instruments (a, b, c) are also utilised to a limited extent. The number of telegraph offices open in the different

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European states is given in M. Vinchent's report; the most important being Germany, with 5,473; France, 4,188; Great Britain, 4,047. The total number of persons employed to conduct the Belgian telegraph service in 1877 was 3,497.

Out of 1,942,957 interior messages, 208 complaints of errors, delay, &c., were received, but *only nine cases of irregularity* were proved to be imputable to the department. In the case of the 957,122 international or transit telegrams, after making the necessary deductions, thirteen irregularities were found to be chargeable to the department.

Expenses.—The total cost of first establishment and extensions to 31st December, 1877, has been 3,804,500f. During the year the expense for working and maintenance—*i.e.*, staff, instruments, material, &c., was 2,589,100f., shewing an increase of 71,370f. over 1876. A further sum of 714,521f. is met by the other branches of the departments of public works and receipts on railway telegraph lines.

Net Cost.—The net cost of dealing with the 4,395,391f. paid and service-messages was 3,277,373f., which would give an average of about 75 centimes per message; but recent researches into the service of 1877, which take account of certain economies of labour, principally by increasing direct communications between the sending and receiving offices, give the following results :—

	Units of Expense.	Net. Cost.	Excess. Receipts. Francs.	Excess. Expense. Francs.
Internal Messages..	14 ...	91 centimes ...		703,861
Interest " ...	8 ...	52 " ...	387,905	———
Transit " ...	4 ...	26 " ...	248,905	
Service " ...	11 ...	716 " ...	636,810	1,071,326
Total..................			F.636,810	F.1,775,187

Total excess of expense over receipts, 1,138,377f. Excess of expense over receipts for private telegrams, 67,051f.

To this total (67,051f.) must be added the expenses of state and conceded railway lines (less the amount received from other departments), 356,805f., which makes the deficit of the telegraph service in 1877 423,856f. Out of 1,000 messages 594 were transmitted direct from the office of origin to the office of destination at a cost per message calculated at 68c. 58; 338 telegrams had two transmissions at a cost of 1·0644f. each; 65 messages were transmitted three times, costing 1·4406 each; three despatches required four transmissions, causing an average net cost of 1·8192f.

A modification of tariff which caused a reduction of four words in the mean length of Belgian internal messages produced a saving of 4½ centimes per ms., or 5·2 per cent. of the net cost; but in the year under review, 1877, this economy, after more careful research, was found to be only 3½ per cent. The elements of expense which have been taken as the basis of these calculations of the net cost of messages apply only to Belgium, which, owing to the small extent of its territory, and denseness of population, occupies an entirely exceptional position in this respect. On the other hand, the nearness of the centres of activity to each other has its disadvantages, because letters, and, above all, post-cards are employed where otherwise the telegraph would be resorted to, and a promptitude is expected from the latter in comparison with the post which is not looked for at longer distances. Belgium is in the first rank as to the use of its *lines*, but is surpassed as to *wires* by Holland and Switzerland. Nine-tenths of the loss of about 703,000f. on the internal traffic was compensated by the profit on international messages, but it is not correct to say, as has been done, that Belgium, in order to obtain this compensation, has received on its international system profits which are not reached or surpassed by other offices. The inequality in the results of internal and international traffic ought to be almost general. It constitutes a very serious argument in support of projects tending to augment internal tariffs in order to lower the international taxes. In what measure can this reciprocatory movement be applied without prejudice to the interests of the most numerous class of correspondents, and without compromising the economical situation, which it is desired to improve? "We do not seek," says M. Vinchent, "to decide this question on the present occasion. We are content to have collected, and rectified by means of the facts accessible to us, some of the elements to be consulted, in order that its solution may not be abandoned to speculation. If the insufficiency of the data obtained is objected to because they are founded on the result of a single working, we shall express our sincere regret at not seeing our way to tap other sources of information. To those who may bring forward the imperfections inherent in studies of this nature, we reply in advance that imperfect data are better than mere suppositions."

In taking leave of M. Vinchent's able report, which is a model of statistics clearly and strikingly arranged, we feel that there are points in the Belgian telegraph service which might be advantageously incorporated in our own. The short message of ten words at three-fifths the ordinary charge, the "urgent" telegram supplying a direct need besides producing a considerable profit to the department, and the delivery of letters and post cards by means of the tramway and omnibus lines, would all be great boons to the public of this country.

Considering the length of time a letter posted in the City takes to reach the suburbs of London, the last especially would meet a long-felt want, and could not fail to be profitable, although it would appear to belong rather to the department of the Post Office than to the telegraph service.

CORRESPONDENCE.

THE MICROPHONE.

TO THE EDITOR OF THE ELECTRICIAN.

Dear Sir: In your number of June 29 appears a letter from "J. Laister," in which he prominently puts forward the fact that Edison had confided to Preece certain facts relating to carbon, and finely divided metals, &c., the principal one of which is the fact that he used a diaphragm, from the vibrations of which he received his variations of pressure, and that Mr. Preece had said, "Had Mr. Edison thrown away his diaphragm he would have forestalled Professor Hughes in this respect, and found that the sonorous vibrations themselves would produce this difference of pressure." This Mr. Edison did do, and a notice of it will be found in *Journal of the Telegraph*, April 16, where he says, "I (Edison) discovered that my principle, unlike all other acoustical devices for the transmission of speech, did not require any vibration of the diaphragm; that, in fact, sound waves could be transformed into electrical pulsations without the movement of any intervening mechanism."

This was written by Edison in the middle of February for Mr. Prescott's book on the Telephone, Phonograph, and other novelties, but appeared for the first time in print April 16. In the same book, on page 37, in speaking of the inflexible plate, he says, "By its use a much greater degree of pressure for any given effort on the part of the speaker is thus brought to bear on the disc than could be obtained if only its small surface alone were used." This, of itself, implies that he well knew that sonorous vibrations themselves would produce this difference of pressure.

Mr. Edison does not set himself up, as Mr. Laister sarcastically remarks, as the fountain of all ideas, nor did he try to make a great "hurrah" when he discovered this principle, but it is certainly strange that *a great discovery* should be proclaimed in England on May 8th, when it had been made public here on April 16, and that Mr. Preece should lecture on it about two weeks later before the Society of Telegraph Engineers, and not mention the fact that Edison had made this statement.

Mr. Laister sarcastically remarks that it is vexing, no doubt, to be forestalled by Bell in the telephone, and Hughes in the microphone. It is not vexing to be forestalled by a discovery like Bell's. Mr. Edison has always given, and at any time will give Bell full credit due to his great discovery, and, although he was using magneto receivers for acoustic telegraphs at the time Bell's discovery was made public, he freely and willingly acknowledged that Bell had got ahead of him in that he had discovered that it was possible to transmit from the same instrument. At that time he suggested to the writer that in our experiments we keep entirely free from the magneto principle in our transmission.

On the other hand, it is vexing that a new principle publicly put forth by Edison in April should be claimed as a great discovery by Hughes in England just twenty-two days after it was published here, amply sufficient time for transit and rediscovery.
—Very respectfully yours, Charles Batchelor.

Menlo Park, N.J., July 14th, 1878.

SINE-GALVANOMETER.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Availing of your kind offer to get information through your column of "Answers to Correspondents," could any of your correspondents give me a *minute and explicit* way of testing in all its branches with a sine-galvanometer; also how to measure the tension of a cell or cells with sine-galvanometer? I must confess I am no mathematician, so that I would deem it a special favour if any of your contributors could, through your columns, teach me this special branch, just as a child learns his alphabet. My earnest desire of learning has made me a correspondent to your excellent journal. I have been baulked everywhere to get this special information. Constant Subscriber.

London, July 18th, 1878.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

We cannot undertake to return drawings or manuscripts, and must, therefore, request Correspondents to keep copies.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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Es wird uns ein Vergnügen sein mit den löblichen Redactionen der deutschen und anderen continentalen Journäle und Zeitschriften, denen die ersten Nos. des ELECTRICIAN *zu Händen kommen möchten auszutauschen.*

I Signori Editori di giornali scientifici che riceveranno i primi numeri dell' ELECTRICIAN *ci faranno cosa gradita accettando il cambio che loro offriamo.*

THE MICROPHONE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: You have asked for the exact dates when I first heard of and received full information regarding Professor Hughes's work. I have much pleasure in informing you that I first heard of it by letter on April 19, and I first saw it at work and received full information regarding it on May 2nd. I may add that I received the *Washington Star* of April 19th on May 5th.—Yours, faithfully, W. H. PREECE.

Gothic Lodge, Wimbledon, July 27th, 1878.

[We have much pleasure in receiving this disclaimer. So far as Mr. Preece's connection with the experiments of Professor Hughes is concerned, the matter should now be at rest.—ED.]

THE TELEGRAPHS BILL.

It hardly requires a Solon to say that the discovery of the telephone was, in reality, the immediate cause for bringing in the Bill we are about to consider. Owing to this discovery, and the action taken upon it by the formation of companies to introduce the apparatus to the public, it seems to us the Government had no option but to bring in a Bill comprehensive enough to preserve the interests of the nation. The first great commercial monopoly of modern governments was letter-carrying, and we doubt if any sane man would for a moment dispute that the greatest possible success has attended this monopoly, and that it is the only method by means of which communication by letter can be perfected. Many go farther, and say that the only way to perfect communication of any kind is by a Government monopoly, and these would have the railways taken over by the State and worked from a central bureau. There is a good deal to be said for such a plan, and much to be said against it. A few years ago, however, it was deemed advisable that the State should monopolise the electric communication of the country, and for this purpose the sum of about ten millions sterling was voted. On Saturday, the 5th of February, 1870, the multiplicity of companies was succeeded by government and central control. In an article written at that time we find these remarks:—"Hitherto, all the inconvenience of divided managements and interests have largely prevented a general use of the electric telegraph for commercial and social purposes. A question of expense has had a similar effect, for a charge of four or five shillings for a twenty-word message to the distant parts of our island necessarily limited the use of the telegraph to those whose means, or absolute necessity, compelled it. A great feature of the new system is the equality of charge that will be adopted." The article goes on to point out other features of interest, such as the simplification of the form in which the message is written, the multiplication of telegraph stations, as well as other conveniences, and we do not think that on the whole the public would be willing to go back to the old days of competition. But competition has its advantages. The great objection to monopoly is that it hinders progress. Dr. Siemens, in his presidential address to the Society of Telegraph Engineers, pointed out that, as regards telegraphic improvements, England was getting behind in the race, and it is singular to find a letter over the signature "Inventor," in *The Times* of July 29, echoing almost the words of the President of the Society. There we read:—"The Telegraph Monopoly Act has already excluded from this country many telegraphic inventions which have proved of considerable public utility in the United States, and which the Post Office will neither purchase and work, nor allow others to work, except on prohibitory terms. In the early days of telegraphic invention the lead was undoubtedly taken by this country; but since the restriction of private enterprise by the Telegraph Act, the United States (the only large country where telegraphs are not under State control) has left us far behind in the race of improvement, and has produced the duplex and quadruplex system of telegraphy, the telephone, &c. I consider, Sir, that the Post Office should adopt all workable inventions, and remunerate the proprietors of them, in accordance with the results obtained; or, at any rate, grant free licences to those willing to run the risk of carrying out telegraphic enterprises in directions unthought of at the time of the acquisition of the telegraphs by the State, and which do not carry on a parallel trade to that of the Post Office telegraphs."

Prof. Graham Bell, and the company interested in his patents, will be found among those who strongly oppose the Bill, as may be gathered from the Professor's letter to *The Times*, and from a deputation waiting on Lord John Manners. The deputation explained to him that the Bill, if it became law, would work a serious injustice upon the Telephone Company in particular, and upon the public in general. It was urged that Mr. Bell had claims to consideration, not only because he was the original patentee, but because he had expended much time and money, acting on a presumed knowledge of the law as it stood, in making his invention of practical and public utility. Mr. Bell worked out his ideas under the belief that he was not affected by the operation of the Telegraph Act, 1869. The members of the Telephone Company had also invested their money under a similar belief. On the part of the public it was protested that inventors would be deterred if the Bill were passed in its present form. Its principle, however, was not controverted. The remonstrants would have the Government monopolise

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the transmission of messages electrically, except in so far as such transmission interferes with their own special invention. The following are the paragraphs which have excited most opposition in the Bill:—

"The expression 'telegraphic line' means telegraphs, posts, and any work (within the meaning of the Telegraph Act, 1863) and also any cables, apparatus, pneumatic or other tube, pipe, or thing whatsoever, used for the purpose of transmitting telegraphic messages or maintaining telegraphic communication, and includes any portion of a telegraphic line as defined by this Act. . . . In the construction of the Telegraph Act, 1869, the term 'telegraph' shall in addition to the meaning assigned to it by that Act include any apparatus for transmitting messages or other communications with the aid of electricity, magnetism, or any other like agency. . . Where an Act of Parliament passed after the first day of January one thousand eight hundred and seventy-eight authorises the construction of any of the following undertakings, namely, any railway, canal, tramway, other than street tramways, highway, bridge, railway or river, embankment, subway, aqueduct, over or across a river, dock, harbour, or pier, it shall be lawful for the Postmaster General, by himself or his agents, to place and maintain telegraphic lines in, under, upon, along, over, or across such undertaking, and from time to time to alter the same, and he may from time to time, by himself or his agents, enter upon any land or works of the undertakers for the purpose of placing, maintaining, or altering any telegraphic line in pursuance of this section, or of examining or repairing any line so placed, and may there remain for such reasonable time, and execute and do all such works and things, as may be necessary or convenient for the purposes aforesaid, but shall not interefere with the traffic along or user of the undertaking, subject to the following conditions: '(1.) In placing, maintaining, or altering such telegraphic lines, no obstruction shall be caused to the traffic along or the user of such undertaking: (2.) The Postmaster General shall not less than one month before he places any telegraphic line give to the undertakers a notice, specifying the course and position of the proposed telegraphic lines, and if within one month after such notice the undertakers object to the course or position specified in the notice, and do not agree with the Postmaster General on some other course or position, a difference shall be deemed to have arisen between the Postmaster General and the undertakers. (3.) If any damage or injury be caused or any stoppage or delay be occasioned to the works of the undertaking by the placing, repair, or maintenance of such telegraphic lines, the Postmaster General shall at his own expense make good such damage or injury, and shall indemnify the undertakers against any expense to which they may be put by reason of any such damage, injury, stoppage, or delay. (4.) If the undertakers shall incur any additional expense by or in consequence of the repair or maintenance of such telegraphic lines the Postmaster General shall from time to time pay to the undertakers the amount of such additional expense.'"

Other paragraphs of the Bill are interesting, but we have sufficient to deal with at present. The portions we have quoted raise the question of continued government monopoly or not. If the company interested in Professor Bell's telephone is to be allowed to erect circuits wherever required, the monopoly of the Government would be at an end. The officials at present employed to work the department may not be so active as our transatlantic friends in the introduction of new inventions. Whether they are justified or not in leaving certain inventions out in the cold is a question worthy of discussion, but surely no one would say that because certain officials do not come up to an ideal standard, therefore the money invested by the country should be thrown away. The framers of the Telegraph Acts evidently intended that the sending of messages should remain solely and entirely in the hands of the Government, and did not mean that any clever inventor who devised a new instrument should be able to take advantage of the more than ordinarily loose wording of an Act of Parliament. It is to obviate this difficulty that the present Bill has been brought forward, and if passed it will, of course, put a stop to the public use of the telephone except when employed in the usual telegraph offices. Whether the instrument is one that would be useful in the hands of the Government *employés* or not is a question we are not called upon to decide. Its claims can be brought before the proper authorities, and if, whilst worthy of adoption, it is rejected by red tapism, its merits can be publicly brought forward, when, sooner or later, a consensus of opinion will be found to have weight, even with a Government department. But its worth must be proved first.

ON THE STUDY OF ELECTRICITY AS A PROFESSIONAL PURSUIT.

BY THOMAS T. P. BRUCE WARREN.

VII.

A balance capable of showing the 1-1000th part of a gramme (1-70th of a grain, about) will enable the operator to work upon a gramme weight of a substance, without involving, if reasonable care be used, greater error than can safely be neglected for a commercial analysis.

I would recommend the student to consider this as *the limit to which he should endeavour to work*, but not to despair if the results obtained at first show that more experience is necessary to reach this standard. The best test you can apply to find out the degree of accuracy is to compare results obtained by different methods. For students who have not the advantage of a tutor, the best plan is to operate upon pure materials which have a definite composition; we have then, as it were, a problem before us with the answer given, and the working out is correct when the answer is obtained. In making even a *qualitative* examination of any substance, it is always best to operate upon a weighed quantity.

Sulphate of Copper:—

Composition. $Cu'' SO_4 . 5 (H_2 O)$.
$= Cu'' O SO_3 . 5 (H_2 O) =$

Cupric Oxide..............	Copper	63·5	
	Oxygen	16·0	
			79·5
Sulphuric Anhydride ...	Sulphur	32·0	
	Oxygen	48·0	
			80·0
Water........................	Hydrogen	10·0	
	Oxygen	80·0	
			90·0
			249·5

Dissolve 2·495 grammes of the salt in distilled water; filter, if necessary, and make up the solution to 100 c.c. Divide into two portions, 50 c.c. each; in one the copper may be determined, and in the other the acid. Acidulate, not too strongly, by adding a little pure nitric acid, and pass through this solution a current of sulphuretted hydrogen, until the blue colour has disappeared, and a few drops of the clear liquid are not discoloured when sulphuretted hydrogen water is added. Whilst passing the gas through it, place the beaker in a water bath, so as to gently heat the liquid.

Filter rapidly, and wash the precipitate with water containing sulphuretted hydrogen.

If a few drops of the filtrate evaporated on a strip of platinum leave no residuum, or a very slight one, we may rest sure that the salt contains no intentionally added impurity, *unless it be water*.

If a large residuum remain, add to the filtrate some strong solution of ammonia, until the liquid is strongly alkaline; the solution becoming immediately blackened indicates the presence of iron, *most probably alone*.

Filter and wash the precipitate with water, to which sulphate of ammonium has been added. Evaporate a few drops of the filtrate as before, and, if no residuum be left when the platinum

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is strongly heated, the absence of alkaline and earthy salts is confirmed. Should a residuum be left, the presence of magnesia, soda, or potash as sulphates may be suspected. If it is required to estimate the iron, this is best done by a volumetric process, and in this case the following method gives good results, although the estimation of the copper necessitates greater precaution being taken from the fact that the divided copper is readily oxidised. A weighted quantity of the salt is dissolved in a platinum or porcelain dish and acidulated with a few drops of sulphuric acid. A few fragments of pure zinc are added, so as to ensure the total reduction of the copper. Sufficient acid must be present to take up the zinc entirely.

The reduced copper is well washed and dried in the same dish and then weighed.

The iron which exists in the liquid can be determined by a standard solution of permanganate potash.

If the analysis has been conducted with proper care the water may be estimated by difference.

In this way an examination of sulphate of copper may be completed in two hours.

To estimate the water by direct weighing, 2·495 grammes of the salt, previously well powdered, should be carefully dried at 212° Fahr. for several hours. It cannot be made to part with all its water without losing some of its acid; but, if dried for 48 hours at 212° Fahr., it will be found to retain from 2 to 3 per cent. of its water.

The amount of acid is determined by precipitating the solution of the salt by adding a solution of nitrate baryta, the precipitated sulphate of baryta being carefully washed, dried, and ignited; the filter being burnt separately, and its ashes added to the dried precipitate. This is necessary, as sulphates heated with carbonaceous matter are decomposed.

2·495 grammes of sulphate of copper should yield 0·8 grammes of sulphuric acid, which corresponds to 2·75 grammes of sulphate of baryta. The same weight of sulphate of copper should contain ·09 grammes of water.

A fair sample of sulphate of copper should not contain more than 2 or 3 per cent. of water beyond this weight, and the amount of iron estimated as ferrous oxide ought not to exceed 1 or 2 per cent. The zinc used in this process should be pure.

In estimating the copper from its sulphide, several precautions are necessary. So long, however, as it is prevented from oxidising by not being too much heated, and great accuracy is not required, it may be weighed direct. 2·495 grammes of sulphate of copper should give ·955 grammes of sulphide (Cu. S.), which will consist of ·635 grammes copper and ·320 grammes sulphur. Where accuracy is required, the sulphide should be carefully removed from the filter and placed in a porcelain crucible, together with the filter-ash, a little sulphur is sprinkled over the surface, and the whole is heated in a current of hydrogen gas, by which it is converted into Cu_2 S.

Fresenius says:—"This method, which was recommended by Bezelius and afterwards by Brunner, has only lately received a very practical form from the apparatus introduced by H. Rose. I feel great pleasure in recommending it. In my own laboratory it is in frequent use."*

From a long acquaintance with the treatment of certain sulphides, I can only add that the method is simply excellent; still it is, in inexperienced hands, likely to give unsatisfactory results. The examination of sulphates by converting them at once into sulphides by this method renders the examination of sulphate of copper and sulphate of zinc so easy and certain that, unless the quantity of iron is large, the copper or zinc present may be determined in the course of an hour or so by the following method:—

Reduce the salt to a rough powder and dry on an oil or sand bath; the loss of acid in this case is not a matter of any consequence. The removal of all the water, so long as spluttering does not take place in the crucible when ignited, is not a necessity.

Introduce the roughly dry powder into the crucible, sprinkle with powdered sulphur, heat at first cautiously, whilst the whole apparatus is filled with hydrogen, after five or ten minutes increase the heat, but avoid such heating that the excess of sulphur in volatilising carries away mechanically any portion of the powder. Finally, the heat may be raised so that the lower portion of the crucible may be intensely red hot. *This must not be continued too long*, especially with zinc sulphide. If the previous heating has been cautiously and slowly conducted, the gas blower should not be used for more than three or five minutes.

I hope that no electrician who wishes to attain to a knowledge of the chemical substances which he employs will omit to fit up this important little piece of apparatus in his laboratory.

It was not my intention to do more than to point out to the electrician the particular methods which I have found in practice to be deserving of his attention, but I have since found that I should probably, by a mere reference to chemical works and processes, deter the student rather than assist him. I have, therefore, thought it better to incur the risk of censure from the experienced analyst, that these papers contain nothing particularly new, than add to the present dilemma, in which electrical students are forced, of finding out for themselves the best way of arriving at any required result or for performing any particular test. One great fault in our more recent electrical works is that the writers have attempted in a small space to cram too much; consequently the *useful* and the *useless* are huddled together, to the embarrassment of the student and the difficulty of deciding by our future writers what is really obsolete and what is practically worth retaining. Equally does this remark apply to writers on chemical analysis; one individual works up some particular process to such a state of perfection that its laudation is loud, whilst the microphone itself would be ineffectual in rendering the merits of equally sound and good methods audible to any one even within his reach. Caprice or our own peculiar mental idiosyncracies always will contribute, more or less, to placing in a false position the values of certain scientific facts. Practice and experience should decide the merits of a process; simplicity, not an artificial training to its comprehension, ought to be the safeguard of its vitality, so long as it links itself with truth.

The volumetric estimation of the copper by means of stannous chloride or any other reducing method would leave nothing to be desired; but, unfortunately, the iron is not always in the ferrous state, and a ferric salt would of necessity introduce an error in making the quantity of copper slightly in excess, since a little of the stannous chloride would be taken up in converting the ferric salt into a ferrous salt.

Stannous chloride requires special precautions to be taken in preserving its solution; otherwise, from the simplicity with which the iron and copper may be estimated, it might become, in spite of the uncertain condition in which the iron exists, so long as its quantity was very small, a good method for this purpose.

By this method the copper and iron are first estimated together by means of a standard solution of stannous chloride. The copper is removed from a fresh portion of a solution of the salt by means of zinc or cadmium free from iron, and the amount of iron contained in the solution determined by a solution of permanganate of potash.

Without some serious modifications this process could not be recommended with samples of sulphate of copper containing *much iron*. I have met with some samples of this salt in which the surface has been covered with ferric iron, as sulphate, oxide, &c. This is much used by agriculturists; its colour agrees more nearly with that of sulphate of iron than that of copper.

There is no difficulty in obtaining sulphate of copper corresponding in purity to the price we want to pay for it. A fair price and a respectable dealer are, as in most things, the best guarantees against fraud.

For the volumetric method we require:—

1. A standard solution of cupric copper.
2. A standard solution of ferrous iron.
3. A standard solution of stannous chloride.
4. A standard solution of permanganate potash.

Solution No. 1 is made by dissolving 15·734 grammes of pure sulphate copper in a litre of distilled water at 60° F.

Solution No. 2 is obtained by dissolving a weighed quantity of clean soft iron wire in dilute sulphuric acid. A special arrangement is required in preparing this solution, so as to avoid every chance of its coming in contact with the air. The solution may contain say 4 grammes of iron per litre. A solution of the double sulphate of iron and ammonia is frequently used in place of this. I would recommend the student to prepare the iron solution as above. The arangement required will be given when treating of the examination of spelter.

The solution of stannous chloride is made by dissolving about 6 grammes *pure grain* tin in strong hydrochloric acid, about ¼ litre, and diluted to 1 litre with pure, fresh distilled water.

The solution of permanganate should contain about 5 grammes in the litre, distilled water used, and the salt dissolved in the cold.

To obtain the sulphate of copper, the best plan is to recrystallize the commercial sulphate from not too strong a solution, so as to obtain small and well-defined separate crystals. To the solution No. 1 an excess of hydrochloric acid is added, which will produce a fine green colour in the solution. This solution, when the smallest trace of copper is present, will show a greenish yellow colour.

We then proceed to determine the relation between the solutions of tin and copper, and also between the iron and the permanganate solutions. 25 c.c. of the copper solution, which will contain 1 gramme of metallic copper, is measured into a colourless

* "Qualitative Chemical Analyses," 7th edit. Vol. I., fol. 258.

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glass flask, and 5 c.c. of pure strong hydrochloric acid added. The flask is placed on a sand bath, and heated to boiling; the tin solution is carefully delivered from a burette until the colour just vanishes. About 5 c.c. more acid is added, and should any colour appear a little more tin solution is required. The process is ended when the liquid is perfectly colourless.

We then know that the quantity of tin solution used exactly represents 1 gramme of pure copper.

As the tin solution varies in strength, however carefully it may be kept, this test should be repeated whenever a fresh sample has to be examined.

The quantity of permanganate solution corresponding to a known weight of iron is thus determined; and, as this solution keeps tolerably well with ordinary care, it is only necessary to test it occasionally.

50 c.c. of the iron solution is transferred by means of a pipette into a beaker standing on a piece of white paper. The solution of permanganate is run in until the last drop added gives a distinct reddish tint to the solution, and which is persistent when it is well stirred up.

We then know that the permanganate solution used exactly corresponds to ·2 grammes metallic iron.

[TO BE CONTINUED.]

STUDENTS' COLUMNS.

GALVANOMETERS.—I.

BY J. T. SPRAGUE, M.S.T.E.

When we examine into the phenomena to which we give the name of the " Electric Current," we find that it involves two sets of facts, intimately connected, yet perfectly distinct and independent. These two classes of facts were grouped by the earlier electricians under the terms, " quantity " and " intensity "—terms which, now abandoned in consequence of the many confusing ideas which became associated with them, and because the progress of science required a wider and also a closer range of verbal appliances, do yet embody truths which the more modern, and, on the whole, better names are somewhat apt to keep out of sight.

We discover, in fact, that there is a something to which the term " quantity" is fairly applicable, and which varies in a direct ratio with the chemical actions which set up the " galvanic " current, and which it, in turn, is capable of producing. We find, also, a second something, which varies in the ratio of the square of the first, or *quantity*, upon which depends the power of the current to overcome resistances, to do mechanical work, or to produce heat or light. This, formerly dimly perceived in the term " intensity," we can now suitably describe only by the term " energy."

There is an important distinction between these, in that the first, the *quantity* (or that to which the term " electricity " is alone applicable) is not expended in the actions effected by the current; its amount is exactly alike in every part of the circuit; it can also convey with it any variable amount of energy according to the circumstances under which it passes through the circuit. The second, the *energy*, is expended, and passes out of the circuit as heat, as mechanical work, and as potential energy stored up in chemical decompositions. Its actions vary in different parts of the circuit, as manifested by the different degrees of " tension " produced by it; it is, however, expended equally throughout the circuit in this sense, that its expenditure in every portion is in the ratio of the resistances of each portion; but that is because the resistance itself is simply due to the expenditure of the energy required to overcome it. It is measurable only by this.

These electrical facts are analogous to those embodied in the ordinary laws of mechanics and motion, electrical *quantity* playing the part corresponding to *mass*, or weight of matter, while the *energy* in all cases takes the various forms of *velocity*, *vis viva*, *mechanical work*, &c.; so that a galvanic circuit bears a very close analogy to a system of hydraulic machinery connected by a system of pipes in which the same water circulates throughout, transmitting the energy imparted to it by the central engine to such points as may be desired.

But, although *electricity*, or electric quantity bears this apparent resemblance to *matter*, and may, as is commonly done, be regarded as a " fluid," there is a growing array of facts which show that either it is closely linked to " molecular " motion, or that it is simply a special influence or effect of molecular motion, and that electricity is no more an existing entity than heat is now generally believed to be, or than mechanical motion is, this latter having obviously no existence apart from the matter which moves.

Electric " quantity," which, with this reserve understood, we may now call " electricity," is intimately connected with the chemical constitution of matter, so that changes of this constitution develop electricity, and *vice versâ*, and they do this so definitely that one known electric quantity or unit corresponds to every kind of chemical change—that is to say, that the electric current which proceeds from or sets up a chemical disturbance of a unit weight of hydrogen will also set up a similar change in any other body to an amount equivalent chemically to the hydrogen unit. This value is not in all cases what used to be called the chemical equivalent, but may be represented in the chemical system now generally adopted as

$$\frac{\text{atomic weight}}{\text{valency}} = \text{electric equivalent.}$$

This chemical relation is rigidly confined to what is called the " circuit"—that is to say, the system of conductors through which the galvanic current actually passes. But, while the " current " is limited to this conducting system, it has external actions, some related to its " quantity," some to its " energy." A current in passing along its conductor sets up a molecular action in its external surroundings, which we call its magnetic effects, and these effects are just as definitely related to its " quantity " as are its chemical effects within the circuit—that is to say, in all cases the magnetism produced by electricity is, in the " ratio of the current," quite independent of any considerations of force or resistance. This is a subject as yet scarcely studied, and really little is known beyond the mere fact; and there is little doubt that the magnetic field when carefully worked will return a rich harvest, and that these molecular relations and connections of chemistry and magnetism to electricity invite the student to an almost new line of work.

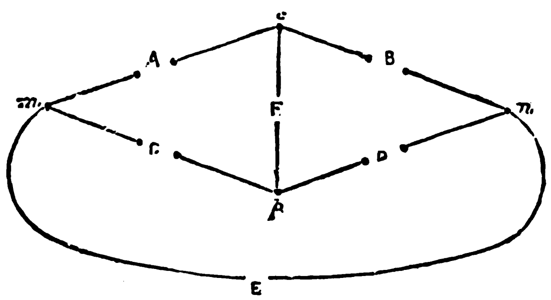
The foregoing considerations show that we have two modes of measuring electricity. 1. By its *energy*. This may be done in several ways, the one commonly adopted being by the heat developed, measured in various calorimeters. This mode, however, involves many difficulties, and is little used. 2. By its *quantity*. Here we have two modes of measurement, the chemical and the magnetic. The instruments for the chemical measurements are called *voltameters*, and are most useful for ascertaining the total effects produced in a given time They may be based upon any chemical reaction, the most common one being the measuring the gases set free in decomposing water, and the most advantageous the ascertaining the weight of a metal (as copper) deposited. The instruments based on magnetic actions are called *galvanometers*, and show the quantity of electricity, from moment to moment, passing in the circuit. The present series of papers will deal with these instruments.

ANSWERS TO QUERIES CONCERNING WHEATSTONE'S BRIDGE.

1. *Mode of Measuring Resistance of Galvanometer by its own Deflection.*

Fig. 2, with galvanometer at D, and battery at E, and a key at

FIG. 2.



F, shows the connections for taking this resistance. Unplug a convenient amount of resistance in branch A and branch C, and then adjust resistance B till such conditions are obtained that depressing the key at F does not alter the deflection of the galvanometer: then we know that the resistances are in the proportion A : C :: B : D, because, if they were not, depressing the key at F would alter the electrical conditions of the circuit, and, consequently, affect the galvanometer. The resistance of the galvanometer can easily be found from the above proportion, and is $D = B\,\frac{C}{A}$, the galvanometer resistance, of course, being the calculated resistance for D.

2. *Method of Measuring the Resistance of a Conductor.*

Referring to Fig. 2, connect galvanometer at F and battery at E. B is the adjustable resistance coil, and D the resistance to be measured. Unplug (if for measuring small resistances) an

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equal amount in A and C, these two branches constituting what is called the "multiplying power of the bridge." Next adjust resistance B till no current passes through the galvanometer at F, when the resistances will be in the proportion A : C :: B : D, and the unknown resistance $D = B\frac{C}{A}$. If the resistance to be measured is very high, C should be made large, say 1,000, and A, say 10, the unknown resistance will equal (the known resistance B) × 100 :—. If very low, C should be 10 and A = 1,000, when D will equal B ÷ 100.

3. *Method of Measuring Internal Resistance of a Battery.*

There are several ways of arriving at the internal resistance of a battery, and Mance's plan is one of the most common. For making this test the galvanometer should be placed at E, and battery at D, and a key at F. Then B must be adjusted till the key F can be depressed without altering the deflection of the galvanometer. Then A : C :: B : D, from which the battery resistance $D = B\frac{C}{A}$.

ALFRED C. M. WEAVER.

SIR: In accordance with the invitation contained in THE ELECTRICIAN, I beg to submit the following question:—

Q. Is not the increase of electro-motive force of one battery over another obtained chiefly, if not entirely, by a more rapid consumption of zinc?

Take, for example, a Grove and a Daniell; the former is said to have twice the power of the latter. Does it not consume twice as much zinc as the Daniell in each unit of time?

Can any of your readers refer me to any published description of experiments on this head? C.E.B.

THE GLOBE TELEGRAPH AND TRUST COMPANY (LIMITED).

The fifth ordinary general meeting of this company was held at the Cannon-street Hotel on Tuesday last, July 30, 1878, JOHN PENDER, Esq., M.P., in the chair.

The Secretary (Mr. Payton) read the notice convening the meeting. The minutes of the last meeting were read and confirmed, and the report was taken as read.

The CHAIRMAN: Gentlemen, I dare say you will observe from the report and the statement of stocks and shares that we have given you a little more information than we did before. There are two new columns which have been added, showing the respective amounts of dividends received from our investments, and the return on cost price, which will make matters clearer to the shareholders. The investments show little change. The 2,000 Direct Cable shares alluded to in last year's report have been taken up, and are now included in our list. The average cost of our Direct shares is 10*l.* 13*s.* 11*d.* per share, which, looking to the market price of the day, is a source of satisfaction. The dividend, as you will observe, is quoted as 3¾ in the List now. This means only for nine months, and not for twelve months, because the dividends for twelve months are at the rate of 5 per cent. per annum, which have been received and which are the first dividends that have been paid by the company, which was formed in 1877. A retrospect of the past two years will show that we have reason to congratulate ourselves on the improved position of Atlantic stocks, and our own shares. At this time, in 1876, Anglos stood at 57¾, and in 1877 at 53¼, now they are at 64. These calculations were made at the end of our financial year, namely, July 18th. They are a little lower to-day, but I am speaking of the period when your accounts were made up. They are somewhat lower since, on account of the failure to repair the 1866 cable. In 1876 Directs stood at 7⅜, in 1877 at 13; they are now about 14. The increase in value in two years has been something like 6 per cent. in the case of the Anglos, and 30 per cent. in the case of the Directs. To put this in plain results, we may say that there has been a rise in Anglo stock equivalent to 420,000*l.* on the whole of the capital, and 67,000*l.* on the stock held by the Globe, and of 390,000*l.* in Direct shares taken as a whole, or 37,000*l.* on the Direct shares held by the Globe. This is attributable to the action of this company in bringing about a working arrangement between the Atlantic companies instead of leaving them to do, by hostile competition, private rebates, and commissions, as much injury as possible to each other. Our own shares have participated in the improvement. A little calculation shows that the total value of our stocks and shares on the 18th July, 1877, was about 2,260,700*l.*, and at present quotations about 2,393,000*l.*, or an increase of 137,306*l.*, or say six per cent. all round, which is an important advance on the year. The value of our own shares, taken at the price of the day, is 2,541,000*l.*, or a value over the stocks and shares we hold in trust of about six per cent. The difference arises from the appreciation of shareholders of the security given by this company in spreading the risks by investment in various companies. Our shares in combination, that is preference and ordinary, taken together, represent a market value of 85 per cent., that is, taking the preferences at 11 and the ordinaries, at 5½ and this is a higher quotation than any other telegraph company now possesses, the submarine alone excepted. Shareholders who have exchanged for Globe shares have nothing, therefore, to regret, but have a materially improved value in their Globe shares as against the stock they exchanged. As regards the revenue account, our receipts, as mentioned in the report, have been augmented by a larger dividend from the Anglo, namely, 4½ this year, as against 3¼ last year, and the first three dividends of the Direct Company, and that enables us to recommend a dividend of 4 per cent. on the ordinary shares, and to carry forward a balance. Our payments are altogether 100*l.* in excess of last year, but this arises from our having to increase our staff, owing to the large increase in the number of shareholders, which, from 2,700 in 1874, has grown to 4,500 in 1878. This large increase and our system of quarterly dividends entail extra expense. The item of Interest on Loans was incurred in respect of the carrying forward of the 2,000 direct shares. It would have been larger had it appeared in the form of dividends on shares issued to pay for the Directs, for we were able to borrow at a less rate than the dividend we are paying. The same observation applies to the loan of 26,000*l.* which appears in the balance-sheet. That amount is borrowed at Bank rate, and it suits us better to wait until our shares reach such a price as will enable us to issue them without any, or, at all events, very little discount. For the next year we have reason to anticipate our revenue with increase. The advance to the River Plate Company in the balance-sheet of 236*l.* 10*s.* will be repaid in a short time. It was a sum we advanced, in common with two other companies, to enable a commission to be sent to Brazil to look into the affairs of the River Plate Company. The mission has been successful, and the prospects of that company are such now, that the item of Globe-holding, although small, will, I believe, be very profitable. The item "interest in suspense," 1,796*l.* 9*s.* 11*d.*, has reference to a former purchase of direct shares. We had to pay interest at the rate of four per cent. per annum until we took them up; but there is a dividend payable on shares as soon as dissentient shareholders are settled with by the liquidation of the Old Direct Company, which will extinguish that item. Now, gentlemen, I have given you these particulars because they immediately bear on the value of your property and also your balance sheet. I do it also for the reason that there are many people who do not understand the position of the Globe Company or the peculiar nature of their property. Some people suppose, because the Globe shares are at a discount, that so much loss has accrued to the shareholders; but in the remarks that I have made you will observe that any man who exchanged his shares in any other telegraph company into the Globe as they stand to-day, will find them of greater value than if they had remained in the company from which he had transferred them. Therefore, the satisfaction is in two ways; you will observe that our shareholders have doubled themselves in number, showing that there is increased confidence in the investment. That there should be increased confidence there ought to be no doubt, because you have all the different telegraph companies contributing, and, consequently, if one is a defaulter, another is paying something extra, and, therefore, in that way you get a fair average; for instance, in our own case, Direct shares have paid nothing until now. The business of the Indo-European Company was interrupted on account of the war for several months, and the consequence was that there was no dividend paid, but they are now working satisfactorily, and they have entered into an engagement with the Eastern Telegraph Company, which will enable them, I hope, in the future to pay a steady and a very fair dividend. As you are aware, this company entirely depends upon the successful working of those companies in which we hold shares. We may be said to be very large shareholders in all these companies. It is the business of the Globe so far to look after their dividends as to see that each company is working up to the points in economy and efficiency in every other way as to ensure to the shareholders a fair and steady dividend [hear, hear]. The more that these companies progress, of course the more the Globe must increase in their dividends. I think now that peace may be said to be established—at least, I hope it is established, and established upon a permanent basis—trade will be emancipated from the extreme depression which has prevailed for so many months, I might almost say years; and with the revival of trade you may depend upon it that there is no Telegraph Company which will not participate in the increase of receipts [applause]. With these remarks, gentlemen, I beg to move the following resolution:—"That the report and accounts of the directors for the year ending the 18th July, 1878, submitted to this meeting, be, and they are hereby received and adopted, and that in accordance with the recommendation of the Board the following dividends be now declared, viz., three shillings per share on the preference shares, making, with previous quarterly payments, 6 per cent. for the year ending 18th July, 1878, and two shillings per share on the ordinary shares, making, with previous quarterly distributions, 4 per cent. per annum for the year ending the same date."

Sir DANIEL GOOCH, Bart., M.P.: I have much pleasure in seconding that motion.

The CHAIRMAN: Before I put the resolution, if any shareholder has any question to ask I shall be very happy to answer it.

Mr. NEWTON: I should like to ask for some information with reference to the Anglo Company, particularly as to the condition of the cable. Is there any intention of issuing the remaining shares of this company? I think, sir, as you show such a great advantage to the holders of the Globe property, you would be doing well to telegraph property generally, and to the Globe especially, if you can increase the holding of telegraph property by exchanging further, and embarking more of your capital in the various companies.

The CHAIRMAN: I think it would not be quite wise on my part if I were to anticipate the statement of the Chairman of the Anglo-American Company, whose meeting is to be held on Friday. I can only say that, so far as I have heard, the core of the cable, that is, the gutta-percha, is now as perfect as on the day it was first put down. But, as I have said, I have no doubt a full statement will be made at that meeting, but I have that faith and belief in scientific progress that I think the difficulties which we begin to realise in this new property of cables are likely to be overcome. I know there are gentlemen present who believe that an Atlantic cable may be made to live for all time. I only wish that proposition could be fairly established, because if it were fairly established the advantage to telegraph companies would be something enormous. However, we will not anticipate what is to be said on Friday, but I trust that science will be able to effect what we hope. As to the issue of further stock, the principle of the Globe is to exchange the shares of the Globe with existing companies, if they can be exchanged at a price which will be satisfactory to the Globe. Therefore I think, although we may consider our books closed at the present time, if we find anything like pressure, or anything like applications of such magnitude from outside people as to induce us to make a further issue, the board will of course consider it. As it is part of the principle of the Globe I should think it would very likely adopt it; in the meantime we do not entertain any proposition just for the moment.

The CHAIRMAN then put the resolution, which was carried unanimously.

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The CHAIRMAN: The next resolution I have to put to the meeting is—"That William Ford, Esq., be and is hereby re-elected a director of the company.

SIR JAMES ANDERSON: I have great pleasure in seconding the motion.

The motion was put, and carried unanimously.

The CHAIRMAN: The next resolution I have to put before you is—"That Sir Daniel Gooch, Bart., M.P., be and is hereby re-elected a director of this company."

Mr. FORD: I have the honour of seconding the motion.

The motion was put, and carried unanimously.

The CHAIRMAN: The next resolution will be moved by Mr. Griffiths.

Mr. GRIFFITHS: Mr. Chairman and gentlemen, I rise with much pleasure to tender our thanks to the directors for their able management during the past year. The unanimity with which you received the report, I think, is a convincing proof that you are satisfied therewith. It is a remarkable statement that our Chairman has made, that the number of shareholders has increased to such a large extent as from 2,700 to upwards of 4,000. Considering that the growth of the society is so large, the fact that so few members are present shows that the report gives satisfaction to the shareholders and public generally. I have glanced over the list of our shareholders, and it certainly contains the names of persons of great influence in all parts of the United Kingdom; and, also, persons of great talent and great scientific skill who are able to judge for themselves. Looking to the facts, I think we have also further cause for congratulation. Last year, the dividend had fallen off on the ordinary shares from the sum of 3s. to 2s., 1s. 9d., and even to 1s. 6d. It is a great thing that peace has been restored, and war is at an end, and that the dividend should again rise to 2s. This, I think, must be a cause of congratulation to us all. On the other hand, we must remember that the cause of the dividend falling off was not due to any fault of our directors, but rather to that spirit of warfare and antagonism which sprung up between the Direct Company and the Anglo-American Company. The warfare was forced on the directors of the Anglo-American by their own company; it was considered necessary. Therefore, although the dividends did fall off, I think the directors of that company were to be commended for the policy they adopted and for the results which have been attained. For those results I believe we are to a great extent indebted to our chairman, Mr. Pender [hear, hear]; he certainly showed great skill in a most difficult crisis. It is a great satisfaction to us that peace is now restored, and our dividend rising again. There is one subject more of regret which our report discloses, and that is that Mr. Cyrus Field has ceased to be a director. The name of Field is so well known in different circles—in political, legislative, and scientific circles, and especially in circles connected with the electric telegraph—it is a cause of regret that he no longer forms a member of our board. You are all probably aware that it is to the family of the Fields that the Anglo-American Company owes its origin, both in the suggestion, and the perseverance, and moral courage which, after so many phases, succeeded in uniting together the two continents of Europe and America. Good men and true men are scarce. Our company is of such large dimensions, and has grown to such magnitude, and its shareholders are so numerous, that we cannot afford to lose any good director. I should be rather in favour of increasing our number of directors, if we could find any equally good. But I think we should pay that debt of gratitude which is due to those gentlemen who are at present in office. They, no doubt, have a stupendous concern to manage, and their management has been distinguished by great skill and considerable success. The name of Pender must give confidence to all persons connected with electric telegraphs; the name of Massey, so well-known in political circles, must also increase our importance; while the name of Sir Daniel Gooch, a host in himself, well-known in the railway world, must add to the *prestige* and strength of our company. It is therefore with the greatest pleasure that I move a vote of thanks to the directors for their able management during the past year. As justice comes before generosity, I think we should also consider the remuneration which is due to them. We have gentlemen of great talent, great skill, and great reputation devoting themselves to our service. In times past we readily voted the sum of 1,000*l*. per annum. I think, under the circumstances, considering the progress of the company, the success which has attended their management, and their reputation with the public, that the least we can do on the present occasion is to vote them 1,500*l*. for their services. It is but a trifle when you consider the magnitude of our capital, nominal or real; it will not make any appreciable difference in the shareholders' dividends—500*l*. out of so many thousands is a mere drop in the ocean. On these grounds I have great pleasure in moving, "That the thanks of this meeting be given to the directors for their able management of the company's affairs during the past year, and recommend that the directors henceforth receive the sum of 1,500*l*. per annum.

Mr. LLOYD: I beg leave to second that motion.

Mr. BURGE: I beg leave to support the resolution. I am the holder of a great many thousand preference shares. I look upon this as the time when some further recompense should be given to the directors in recognition of their services. A year ago a great attack was made upon the chairman in a paper which is stranger than fiction. I think the directors of this company had to undergo the most powerful castigation unjustly that was ever imposed. They have carried us through a period of great trial and difficulty. I believe they have done a great deal to rescue from a large loss a very valuable property in the Atlantic. I think when we the shareholders of this company entrust to them capital to the extent of two millions-and-a-half, they have a very serious charge, and I do not understand how we can expect gentlemen of their reputation and position to undertake the responsibility of looking after that upon the same terms as those upon which they started, because they represent each shareholder. If we were private shareholders, considering the various companies that are in existance, we should take a very great deal of time to see that the company's affairs were well managed. I do not understand how our directors can be expected to look after the business of twelve or thirteen different companies unless they are a little more fairly remunerated. I think the trouble and difficulty which they have had to encounter, and the malignity with which they have been attacked in the Press, should cause us to recognise their value. I think, if we have an income of 150,000*l*. or 160,000*l*. a year dependent upon their exertions, that 1,500*l*. a year is not too much to give them in return. I have the greatest possible pleasure in supporting the resolution moved by Mr. Griffiths. I do not know one of the directors personally, but I cannot help thinking that we should be only doing justice to men who are looking after our interests to such an extent by remunerating them a little more handsomely [hear, hear].

Mr. GRIFFITHS then put the resolution, which was carried unanimously.

The CHAIRMAN: Gentlemen, I beg to thank you on behalf of my co-directors and myself for this renewed proof of your confidence. I dare say it will be in the recollection of some of the gentlemen in this room that shortly after this company was formed, I think about a couple of years, there was a motion made that the directors' remuneration should be 2,000*l*. I do not remember the name of the gentleman who made it, but I, on the part of my friends sitting around me, declined any increase upon the 1,000*l*. until we had got the company into a thoroughly satisfactory position. I think we are placed before you to-day in a very satisfactory position [hear, hear]. What one of the gentlemen who has just spoken said, that we have been very much maligned, is quite true; but, as long as men feel that they are doing their duty, and can show good results from their action, they are in the proud position of being able to treat with the most perfect contempt all attacks that may be made upon them, from whatever quarter they may come [hear, hear, and applause]. But, gentlemen, if we have the confidence of the body of shareholders (and we will only hold that confidence as long as we can show results) you may depend upon it your interests will be protected, and those who make those attacks which have been referred to, will in the end feel that they are rather doing us good instead of harm [hear, hear]. With these remarks I beg to thank you very much for the confidence you have reposed in us to-day. It is a very unusual thing indeed for a meeting to be so unanimous as you have been in increasing the directors' fees. I do not think that at any meeting which I have ever attended I have seen so much unanimity as I have to-day. You may depend upon it, it will have its proper effect upon the directors [applause].

Mr. NEWTON: I do not interpose, because I am a preference shareholder. I think that the resolution which has just been carried should have been proposed by an ordinary shareholder, seconded by an ordinary shareholder, and supported by an ordinary shareholder. I beg to say that I thoroughly oppose it. I did not vote against it, because I am only a preference shareholder. I have great pleasure in moving, "That William Newmarch, Esq., F.R.S., and John George Griffiths, Esq., be and are hereby re-elected the auditors of this company for the current year, at a remuneration of thirty guineas."

The CHAIRMAN: I always like, as far as one's knowledge goes, to give the shareholders the full benefit of my information. I may mention to Mr. Newton that he has a perfect right, as a preference shareholder in this company, to move or vote as he pleases. There is another company, at a meeting of which he made a motion, as he is aware, in which he was out of order; but, when this company was dealt with, it was thought better to amend the articles of association, so as to enable the preference shareholders to vote as well as the ordinary shareholders. I think, notwithstanding the remarks of Mr. Newton, who I know is a great economist, that there is not any man in this room who will more readily admit that the labourer is worthy of his hire [hear, hear]. I think that Mr. Newton will admit that during the time that we had that very hazardous battle to fight, and in which I do honestly believe that we rescued the Direct Telegraph Company from ruin, and I express my belief, although I may not have the concurrence of every gentleman in doing so, that it could be proved that the gain not only to this company, but to telegraphy as a property, was very great indeed. If Mr. Newton had been working with us, and paid at the rate we were paid, I suspect he should have had a very poor dinner to dine upon [laughter].

Mr. NEWTON: I am quite aware you gave us, the preference shareholders, the right to move and vote in this company; but I feel equally confident that I have the same right elsewhere.

The CHAIRMAN: Now, you will allow me to remind you that you are out of order.

Mr. OXENFORD: I beg leave to second the motion.

The motion was then put and carried unanimously.

The CHAIRMAN: I may mention that Mr. Burge, Mr. Griffiths, and Mr. Oxenford, are all ordinary shareholders.

Mr. McLAREN SMITH: May I be allowed one word of explanation? I held up my hand against that motion, and the reason I did so was this: I think this company was formed, not as a trust company, but to carry out a very different object. That I believe the directors are not doing. When once they are doing so I shall be very glad that they shall be remunerated on a more liberal scale.

The CHAIRMAN: If any gentleman holding shares in any other company will come forward, we are prepared to exchange Globe shares with him, but we cannot force that upon the other shareholders, that is not our business.

Mr. McLAREN SMITH: You may invite them.

The CHAIRMAN: We have done that periodically, and are not likely to do that again, because the expression of feeling so far has been against it. As I said before, if we find that shareholders in other companies are anxious to exchange into the Globe, we shall be glad to receive them. I think I have taken some pains to-day to show you by figures and facts that the Globe Company, with the exception of the Submarine Company, stands at the head of submarine telegraph companies as to the value of its property. I have also said that the reason of that is because it gives additional security. Beyond that I have nothing further to say. The general body of the shareholders must judge for themselves; but, if they are prepared to come into the Globe, we shall receive them with the greatest possible satisfaction. I think that that terminates the business of the meeting.

ANGLO-AMERICAN TELEGRAPH.

The report states that the total receipts from January 1 to June 30, including a balance of 3,228*l*. brought over from the last acount, amount to 274,386*l*. The total expenses of the half-year, including income-tax and repair of cables, as shown by the revenue account, amount to 44,265*l*. The directors, under the powers conferred upon them by the articles of association, have, before declaring the net profits, set apart the sum of 75,000*l*. to the renewal fund, leaving a balance of 155,120*l*. One quarterly interim

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dividend, of 2 per cent. on the preferred stock, and at the rate of 4 per cent. per annum on the ordinary stock, free of income-tax, was paid on May 1, 1878, absorbing 70,000*l.*, leaving a balance of 85,120*l.*, from which a second quarterly dividend at the same rates will be paid on August 1, 1878; leaving a balance of 15,120*l.* to be carried forward to the next account. The increase in the traffic receipts for the first six months of 1878, as compared with the corresponding period in 1877, amounting to 67,308*l.*, is explained by the fact that the 3s. rate has been in force during the whole of the six months, whereas, in 1877, it was only partially maintained for four months. At the commencement of the present year the question of making another effort to repair the 1866 cable was the subject of anxious consideration by the board, and an expedition has been despatched for that purpose. The company's repairing ship, the *Minia*, has been employed during a part of the past half year by the Direct United States Cable Company in the recovery of their cable between Torbay, N.S., and Ryebeach, U.S.A. The company's deep sea cables, laid in 1869, 1873, and 1874, are in perfect working order and condition. The Duxbury Cable was broken on May 14 last, in nearly the same spot upon which it had been injured on several previous occasions. The board has decided to remove the cable into safer water, and the *Minia* is now engaged upon this work. The inter-island cables between Newfoundland and a point near Cape Breton are in good working order.

THE DIRECT UNITED STATES CABLE COMPANY (LIMITED).

Abstract of the report of the directors, to be read at the second ordinary general meeting of the Company on Friday, August 2, 1878:—"The directors submit herewith the accounts for the six months ending 30th June, 1878, which accounts complete the first year's working of the reconstructed company. The revenue for the last half-year, after deducting payments to the associated companies, amounted to 79,852*l.* 11s. 5d., and the working expenses, cost of repairs, interest on debentures of old company, income-tax, &c., amount to 29,725*l.* 14s. 10d., leaving a balance of 50,126*l.* 16s. 7., being the net profits of the half-year. Three quarterly interim dividends of 1¼ per cent. each, amounting to 45,532*l.* 10s. 0d., have been paid during the year. The directors now propose a final dividend of 5s. per share, making, with the three quarterly interim dividends mentioned, 5 per cent. for the year, or a total of 60,710*l.* Having regard to the strong opinion expressed and approved at the last general meeting that the dividend should not be increased beyond 5 per cent. until a substantial reserve fund is established the directors have considered it expedient to add 32,155*l.* 3s. 0d. to that fund, which will thereby (with the previous appropriation of 12,500*l.*,) be increased to 44,655*l.* 3s. 0d.; against this the payment of 4,655*l.* 3s. 0d. to the Anglo-American Company, in settlement of the accounts for May and June, 1877, has been charged, leaving a sum of 40,000*l.* to the credit of the reserve fund. The directors have further written off 1,000*l.* of the preliminary expenditure, leaving a balance of 2,933*l.* 3s. 7d. to the credit of the revenue account. The experience now acquired of the working of submarine cables renders it a primary duty of directors to secure as far as possible the permanency of the property by the practical guarantee of a substantial reserve fund against the contingencies of breaks and competition. The interruption to the company's short cable, which occurred on the 17th of January, as notified in the 7th paragraph of the last report, was occasioned by a ship's anchor hooking the cable. The directors regret to say that their anticipations of a speedy repair of the cable were not realised in consequence of fogs and bad weather prevailing from the time the *Minia* left the harbour up to the 1st day of June, when the repairs were completed. The cost of this expedition amounted to £9,659 17s. 1d. The two breaks during the first year's working of the company have cost £13,519 8s. 10d., which has been debited directly to revenue. Fortunately for the proprietors, the established relations of the company with the Anglo-American Company have averted the loss of revenue which would otherwise have resulted from the breaking of this short section. The directors have much satisfaction in reporting that negotiations are now proceeding between this company and the Dominion Telegraph Company, which it is believed will terminate all existing difficulties with that company, and result in a supplemental working agreement beneficial to both companies.

TELEGRAPH SHARE LIST.

Amount of Issue.	Amount of Share.	Paid on Share.	Company.	Reserve as per last Report.	Dividends calculated at rate per cent. per annum. 1875. %	1875. %	1876. %	1876. %	1877. %	1877. %	When Payable.	Prices. 1875. Highest.	1875. Lowest.	1876. Highest.	1876. Lowest.	1877. Highest.	1877. Lowest.
£3,254,580	Stock	100	P Anglo-American	Deferred receiving no dividend		year.	5	4†	3	5	† Div. 5 % per ann. for quarter ending Dec. 31, 1876, 2% for quarter ending Mar. 31, 4 % for quarters	75½	51½	68½	53	62¼	52
1,872,710	Stock	100	Do. Preferred B	until 6 per cent.	—	—	10	2	6	6	ending June 30 and Sept.	Crtd	1876.	93	75	88½	79
1,872,710	Stock	100	Do. Deferred A	has been paid to Preferred.	—	—	Nil.	6	Nil.	4	30, 6 % for quarter ending Dec. 31, 1877, and 4 % for quarter ending March 31, 1878.	Crtd	1876.	44	29	38	25⅝
1,300,000	10	All	Brazilian Submarine	120,000	5	5	5	5	5	5	Quarterly.	7¼	6	7¾	5¼	6¾	5⅞
160,000	10	All	Cuba (Limited)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60,000	10	All	Do. 10 per cent. Preference	—	—	—	—	—	—	—	—	—	—	—	—	—	—
116,379	10	9	Direct Spanish (Limited)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
58,430	10	All	Do. 10 per cent. Preference	—	—	—	—	—	—	—	—	—	—	—	—	—	—
65,000	20	All	Direct United States	Nil.	—	Nil.	Nil.	Nil.	Nil.	5	Quarterly.	13	7	11½	6¼	13⅜	9½
369,700	10	All	Eastern (Limited)	110,000	5	year.	5	5	5		*a*Jany., April, *July*, Oct.	8	6⅜	7⅛	5	8¼	6⅝
232,000	100	All	Eastern 6 per cent. Debentures	—	—	—	—	—	—	—	—	—	—	—	—	—	—
200,000	100	All	Do. 5 per cent. Debentures	—	—	—	—	—	—	—	—	—	—	—	—	—	—
700,000	10	All	Do. 6 per cent. Preference	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,997,500	10	All	Eastn. Exten. Australasia & China	125,404	5½	year.	5	year.	5	year.	*a*Jany., *April*, July, Oct.	8¼	7	7½	5⅛	8	6⅝
320,000	100	All	Eastn. Exten. 6 p.c. Deben. (1875)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
192,680	10	All	German Un. Tl. and Tst.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,500,000	10	All	Globe Telegraph and Trust	Nil.	5	7 4–5	4½	7 5–6	3⅝	7 6–7	*b*Jany., April, *July*, Oct.	6¾	5⅛	5⅞	4¼	5¼	4¼
1,500,000	10	All	Do. 6 per cent. Preference		6	6	6	6	6	6	Jany., April, July, Oct.	10½	9¾	10⅜	9¼	10½	9¼
150,000	10	All	Great Northern	85,543	5⅝	year.	6⅝	year.	6⅝	year.	5 % intrm. Jan. 1, July 1.	11½	7½	9¾	7	8	7
			Shares to Bearer, or can be Regstrd.								Final Dividend April.						
—	25	All	Indo-European	—	—	—	—	—	—	—	—	—	—	—	—	—	—
120,000	10	All	Mediterranean Extension (Lmtd.)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
32,000	10	All	Do. 8 per cent. Preference	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	18	All	Reuter's (Limited)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
65,000	10	All	West India and Panama	16,000	Nil.	Nil.	Nil.	Nil.	1	1	‡ Converted from a 10 %	4¾	1⅝	2⅛	⅝	3⅝	1½
34,563	10	All	Do. 6 per cent. Preference		7/6ac	year.	10/ac	year.	6‡	6	into a 6 % 1st Preference.	12	9	11	7	11	7½
67,500	20	All	Western and Brazilian	7,793	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Half-yearly.	18¼	9½	10⅜	4¼	5¾	4⅝
$1,500,000	$1000	All	Western Union Telegraph 7 per cent. First Mortgage Bonds	—	7	7	7	7	7	7	May, November.	108	102½	109¼	105	113	106
£1,030,000	200	All	Do. 6 per cent. Sterling Bonds	Redeeemable by annual drawings at par.	6	6	6	6	6	6	March 1, September 1.	93	86	98	89	101	94

a Year ends March 31st. Interim Dividend of 5 per cent. Final dividend in July. *b* Year ends July 18th. Final dividend in July.

Companies.	Closing Prices 31st July.		Business Done Week Ending 31st July. Highest.	Lowest.
Anglo-American	61½,	62	62½	61⅝
Do. B.	90½,	91	91¾	90½
Do. A.	34½,	35½	36	34¾
Brazilian	6¾,	7	7 1-16	7
Cuba	9¼,	9¾	—	—
Do. Ten per Cent. Preference	17,	17½	17½	16¾
Direct Spanish	1½	2	—	—
Do. Ten per Cent. Preference	9½	10	—	—
Direct United States	13¾,	14	14½	13¾
Eastern	7⅝,	7⅞	7⅞	7 11-16
Do. Six per Cent. Debenture	108,	111	—	—
Do. Five per Cent. do.	103,	105	—	—
Do. Six per Cent. Preference	11¾,	12	12	11¾
Eastern Extension	7½,	7¾	7 11-16	7⅝
Do. Six per Cent. Debentures	109,	112	—	—
German Union	8½,	9	—	—
Globe Telegraph and Trust	5½,	5⅝	5 13-16	5 7-16
Do. Six per Cent. Preference	10¾,	11½	11½	11
Great Northern	8¾,	9	8¾	8¾
Indo-European	20,	21	20½	20½
Mediterranean Extension	3,	3½	3 1-16	3 1-16
Do. Eight per Cent. Preference	9½,	10½	—	—
Reuter's	10,	11	—	—
West India and Panama	2½,	2⅝	2½	2⅝
Do. Six per Cent. Preference	8½,	9	8 13-16	8¾
Western and Brazilian	4½,	4¾	4¾	4¾
West. Union 7 p. Cent. 1st Mortgage	116,	120	—	—
Do. Six per Cent. Sterling	102,	104	—	—

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OUR SUPPLEMENT.

We have this week the pleasure of offering our readers a Supplement containing Diagrams to illustrate various Papers given or commenced in this number.

Figs. 1 & 2	on the first page	illustrate	Mr. Schwendler's Galvanometer.
„ 3 to 8	„	„	The Improved Hughes Apparatus.
„ 9 to 12	„	„	The Improved Test, by O. Lodge, D.Sc.
„ 1 to 4	second page	„	The Duplex System of De Sussex.
„ 1 to 3	„	„	Mr. Edison's Micro-Tasimeter.

NOTES.

The Real Inventor of the Telephone.—An article in a recent number of the Pekin *Gazette*, written by Chin Hoo, says Kung Foo Whing, a distinguished philosopher who flourished about the year 976, invented the telephone—which is known in China as "Thumthsein"—in the year 968!

The Electric Light at the Gaiety.—The Gaiety Theatre is the first public building in London illuminated by the electric light. This has just been done with entire success. The impression of some visitors from the country was that half a dozen harvest moons were shining at once in the Strand.

Pension to Dr. Prescott Joule.—Dr. Joule, of Manchester, whose name is inseparably connected with the theory of the mechanical equivalent of heat, and who has done for the laws of current energy what Ohm accomplished in relation to the laws of the voltaic current itself, has, we are glad to learn, been granted a civil list pension of 200*l.* per annum.

The Cape Telegraphs.—The *Journal Télégraphique* states there are from four to five thousand miles of telegraph line in operation in our South African colonies—exclusive of the Transvaal—which serve 88 widely separated localities. This system is divided into three districts, with an increasing tariff for transmission to each district, the lowest charge being 1s. 6d. between any two parts of the same district.

The Jurors at the Paris Exhibition and the Telephone.—Experiments with a combination of the telephone with the phonograph were made before the jurors at the Paris Exhibition. After conversing for some minutes with the Bell and the Edison telephones between Versailles and the Exhibition, a telephone was placed at the mouth of a phonograph, which transmitted to Versailles the words pricked off half an hour before on the cylinder at Paris. Then the interlocutor at Versailles sung in the telephone, and by the aid of another telephone the song was inscribed on the phonograph at Paris and repeated several times.—*Engineer.*

The Late Total Solar Eclipse.—On this occasion decisive spectroscopic evidence was for the first time obtained as to the intense heat of the minute particles which probably form the sun's corona; and it is remarkable, therefore, that this heat should also have been actually measured. Upon another page we illustrate the instrument (one form of the microtasimer), by which this measurement was effected. It was employed to compare the heat received from parts of the sky remote from the eclipsed sun with that received from the corona; and it gave the clearest possible evidence of the fact that heat as well as light comes to us from this vast solar appendage.

Duplication of Cables to Australia.—We gather from the Australian papers that the results of the recent Telegraphic Conference meet with the approval of the public. The Conference was presided over by the Chief Secretary of Victoria, and was attended by representatives of New South Wales, Queensland, South Australia, and Tasmania. The whole question of duplicate cable communication with Europe was considered, and it was resolved to accept the proposal of Colonel Glover, on behalf of the Eastern Extension Telegraph Company, to lay a second cable within eight months from the signing of the contract from Singapore to Port Darwin for an annual subsidy of 32,400*l.* for twenty years.

Stewart's Flag-Signal for Railway Carriages.—This signal, as shown at the Paris Exhibition, appears to be clearly an improvement upon the ordinary signals by pulling a cord or touching a spring, which are so often ineffective through neglect in establishing the connections in making up the train. In Mr. Stewart's invention, the pulling of a cord, accessible from any part of a carriage, is at least certain, even in prevalence of this neglect, to cause the protrusion from the side of the car of a red flag which, unfurling itself and fluttering in the wind, is pretty certain to attract attention within a very short period of time. But the pulling of the cord should also, when certain very simple connections are duly made, cause an electric bell to ring continuously in the guard's van. A Leclanché cell is the electrometor used for producing this effect.

The Opera at Home.—A curious micro-telephonic experiment is reported from Switzerland. An Italian opera company having announced *Don Pasquale*, one of the telegraph inspectors of the district fitted up in a first-row box near the stage, a Hughes carbon microphone, connected by two wires of 1½ mm. diameter, to four telephone receivers placed in a billiard room near the theatre. In circuit with the microphone was a small battery of two cells. The result was completely successful. The telephones reproduced exactly the efforts both of the vocalists and of the orchestra, and several critical auditors, under these novel circumstances, testified that they did not lose a note or a tone. The same results were obtained on introducing into the circuit a resistance of ten kilomètres without increasing the number of cells. The well-known lightness and grace of the music of the opera thus experimented upon show us what sensibility can be afforded by a combination of the instruments of Hughes and Bell.

Telegraphy in the Colony of Victoria.—The telegraph arrangements are very extensive, and amply sufficient for the requirements of the colony, extending in every direction, and having stations in every important township and centre of population. The telegraph lines in Victoria extend over 2,629 miles, the wires measuring 4,510 miles. They are connected with the lines of New South Wales, and by means of them with those of Queensland and New Zealand. They are also connected with the lines of South Australia, and through them with those of the Eastern Archipelago, Asia, and Europe, and will be shortly connected with those of West Australia. They are likewise connected with those of Tasmania, by means of a submarine cable reaching from Port Phillip Heads to Low Head, at the mouth of the Tamar river. The number of telegraph stations in Victoria is nearly 200. The rate for telegraph messages within the colony is an uniform one of 1s. for ten words, exclusive of the address.

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and 1d. per word additional. The rates for the other colonies are somewhat higher, and a special charge is made for cablegrams. The first telegraph circuit was opened at Melbourne in 1854.

Electric Light.—For some months past the spinning factory of MM. David Trovillier and Adhémar, at Epinal (Department of Vosges, in France) has been illuminated by the electric light, and the results obtained are considered most satisfactory. A space of 1,314 square mètres is lit up by four lamps, furnished with ground glass globes and placed $3\frac{1}{3}$ mètres above the floor. Compared with the light obtained by means of the sixty gas jets that were formerly used, the electric illumination is very powerful; but, far from complaining of any fatigue resulting from so intense a light, the workpeople prefer it to gas. Thus, when the proprietors ran short of the carbon rods used in the lamps, a deputation waited upon them to say that they hoped the electric lighting would be resumed. By giving due care to the proper reflection of the light, deep shadows are altogether avoided; and even the interior portions of the machines, where no direct rays can penetrate, are illumined by the reflected light. The walls of the factory are whitewashed. One of the most important of the results observed is the absence of any perceptible heating effect upon the atmosphere, even when the work of the factory is continued throughout the night. The power requisite to work the magneto-electric machine producing the light is obtained without difficulty from the hydraulic prime-motor which works the spinning machinery. At Rouen, M. Manteau lights up his weaving factory by electricity; and the square of the *hôtel de ville* is often illuminated by six electric lights, the effect of which cannot be compared with that obtained by any other system of lighting.

The Variations in the Intensity of Currents Transmitted through Imperfect Contacts according to the Pressure Exerted between them.*—One of the most interesting modes of demonstrating the variations in the intensity of currents transmitted through imperfect contacts, according to the pressure exerted upon the latter, is to wind upon a glass tube a helix of copper wire (say No. 16), without any insulating covering, and then to fix to the ends of the tube an appliance for compressing the spirals. When this means is employed we observe that when the compression of the turns of wire, one against another, is very small, the resistance of the wire of the helix *is but little less than what it would be if the wire were completely covered with silk, and that this resistance constantly diminishes with the compression until the latter arrives at its maximum.* When the wire is bright the effect is less marked than when it is slightly oxidised; nevertheless, it is even then very appreciable; and since an inverse effect is produced when the compression is slackened, we cannot attribute this effect to a simple action of the layer of oxide which may have formed upon the wire. I had made the experiment in 1864, at the time when I laid before the Academie des Science the electro-magnets, with uncovered wire of M. Carlier instruments, which at that period attracted much attention in the scientific world, and which are, even in our days, advantageously employed in certain circumstances—for example, to avoid the sparks of the extra current. In 1865 I published a long memoir in the *Annales Télégraphique* on the effects produced with this interesting apparatus, and I even quoted the experiment above mentioned (see vol. viii., p. 211). I think we have not hitherto sufficiently considered the physical effects produced at the points of contact of conducting bodies traversed by a current. There is positively a resistance to the passage, which varies with the pressure exerted upon the contact pieces. Is this effect to be accounted for on the hypothesis that the surface of contact may become better developed in consequence of this pressure, the action being equivalent to an augmentation of section in the conductors?—or should we attribute it to repulsions occurring between the contiguous elements of the same current, which, being effected with greater facility with slight contacts than with better contacts, would tend to be destroyed by the latter?—or, again, should they be ascribed to the molecular variations which produce sounds in microphones employed as receivers? Such are the ideas which occur to one whilst observing the phenomena, but these ideas require investigation, and to this point I would direct the attention of experimentalists.—Th. du Moncel.

* *La Correspondance Scientifique.*

The Microphone.—The following important contribution to the controversy relative to the invention of the microphone has been addressed to our contemporary, *Nature*, by Sir W. Thomson, F.R.S.:—"The pleasure with which those beautiful discoveries and inventions, the telephone, the phonograph, and the microphone, have been appreciated by the world, has been unhappily, and I must say I think unnecessarily, marred by one of the most disagreeable things that can be thrust on the public—a personal claim of priority, accompanied by accusations of bad faith, especially when made against any one of whose name and fame the public has come to feel concerned. Before troubling the public at all with such a matter, Mr. Edison might surely have reasoned out his claim with Mr. Preece, with whom he had been from the beginning in correspondence, or he might have written immediately to public journals, calmly pointing out the close relation between his own 'carbon telephone' and Mr. Hughes's subsequent 'microphone.' The scientific public could then have calmly judged, and would have felt much interest in judging, how much in common or how much not in common there may be in the physical principles concerned in the two instruments. But by his violent attack in public journals on Mr. Preece and Mr. Hughes, charging them with 'piracy' and 'plagiarism,' and 'abuse of confidence,' he has rendered it for the time impossible for either them or others to give any consideration whatever to his claims. Nothing can be more unfounded than the accusations! Mr. Preece himself gave, at the Plymouth meeting of the British Association last August, a clear and thoroughly appreciative description of Edison's carbon telephone, and published it in the printed reports of his lecture which appeared in the public journals. The beautiful results shown since the beginning of the present year by Mr. Hughes with his microphone were described by himself in such a manner as to leave no doubt but that he had worked them out quite independently, and that he had not the slightest intention of appropriating any credit due to Mr. Edison. It does seem to me that the physical principle used by Edison in his carbon telephone and by Hughes in the microphone is one and the same, and that it is the same as that used by M. Clérac, of the French 'Administration des Lignes Télégraphiques,' in the 'variable resistance carbon tubes,' which he had given to Mr. Hughes and others for important practical applications as early as 1866, and that it depends entirely on the fact long ago pointed out by Du Moncel, that increase of pressure between two conductors in contact produces diminution of electric resistance between them. I cannot but think that Mr. Edison will see that he has let himself be hurried into an injustice, and that he will therefore not rest until he retracts his accusations of bad faith publicly and amply as he made them."

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TELEGRAPHIC APPARATUS FOR DUPLEX TRANSMISSION.

BY S. W. DE SUSSEX.

Polarisation of the Poles of a Magnet.—If a permanent magnet A, in the form of a horse shoe, has its arms prolonged by pieces of soft iron, the magnetic poles of the primitive magnet will be transferred to the extremity of the soft iron, that is to say, the south pole to *a*, and the north pole to *b* (fig. 1). Now direct a current around the soft iron bars B, by means of coils. The current will act upon the bars of soft iron fixed to the permanent magnet. If, at the moment when the current is passing through, we place a magnetic needle near the extremity *b* of the magnet A, prolonged by the soft iron bars B, we shall see this bar deviate considerably from its original position, indicated by fig. 2. And, if the current be of sufficient intensity, the needle will be reversed, its pole *b'* will turn towards *b*, thus indicating to us that at the extremity of the soft iron extension of the magnet A, and at *b'*, we have produced a southern pole, that is to say, at this extreme point, a complete reversal of the magnetism of the primitive magnet A. In other words, the two arms become by the passage of the current two electro-magnets, the communication of which, with the permanent magnet A, nevertheless, does not modify the poles of the magnet A. The same thing takes place in an opposite direction with the extension of the other pole, since we have taken for granted the simultaneous passage of the current in the two coils.

A magnetized Armature of Steel or Soft Iron is repelled from the Poles of a Magnet.—Let us place beneath the arms, and at a very short distance from them, an armature of soft iron, or of magnetized steel (fig. 2). At the moment of the passage of the current this armature is repelled. In fact, if the armature is of magnetized steel, and such that its north pole lies under the south pole, and its south pole (under the north pole of the permanent magnet A, this armature, at the moment of the passage of the current, will be repelled by the prolonged poles of the magnet A, which, as we have shown, become of the same kind as those of the extremities of the armature of magnetized steel. If, on the contrary, this armature is of soft iron, it becomes, in fact, magnetized by the induction of the permanent magnet A, and its poles are similar to those in the case of a magnetized armature; thus, on the passage of the current, the same phenomenon of repulsion will be observed.

Application to the Construction of Telegraphic Receivers.—Let us remove the call-spring of a telegraphic receiver, and replace it by a permanent magnet prolonged by arms of soft iron surrounded by coils, as indicated in figure 2. We have fixed these coils in such a manner as that the circulating current shall polarise the prolonged poles of the permanent magnet A, whilst at the same time determining, in an electro-magnet placed below the armature, a magnetism of the same kind as that of the permanent magnet A. It is clear that we shall have obtained an attraction of the armature by the lower electro-magnet thus formed, at the same time having determined a downward repulsion of this armature, a repulsion due to the formation of the upper electro-magnets. This phenomenon will continue till the moment when, the interruption of the current withdrawing all magnetic action from the various electro-magnets, the permanent magnet A alone becomes active, and, being extended then to the extremity of the arms which prolong it, brings back the armature to its original position. There is here a differential action, and the equilibrium being well established by the adjustment of an instrument thus constructed, will allow us to work it with a very much reduced electro-motive force; since, whatever this force may be, there will always be attraction on the one hand and repulsion on the other.

Special Application of the Receivers.—It is in accordance with these observations and these data that we have constructed an instrument which can be adapted to ordinary telegraphic receivers. Here, for instance, is a description of this instrument applied to the Morse system. In the ordinary Morse instrument the point, by means of which the whole of the signals are reproduced on the paper which is unwound by the clockwork, is supported by a lever, which at its other end supports the armature of an electric magnet. This armature is kept at a distance from the electro-magnet by means of a small spring. When a current from the line passes into the coils of the electro-magnet the armature is attracted. On the other hand, it follows from our first explanation that if, instead of keeping the armature at a distance from the poles of the electro-magnet by means of a spring, we keep it at a distance by the permanent magnet A, we shall have a magnetic spring in place of a mechanical spring. But at the moment of the passage of the current this spring will be repellent, whilst below we shall have excited by the lower electro-magnet an attractive force. The armature will thus be doubly attracted, and will lower itself, and rise again only on the interruption of the current.

Explanation of Fig. 3, showing the whole of a Morse Receiver furnished with the Apparatus.—Fig. 3 shows in principle the construction of our apparatus applied to a Morse receiver. A is the permanent magnet; R the regulator, of soft iron, working by means of a rack, in order to allow the force of the permanent magnet A to be increased or diminished at will. There is a screw which by means of a brass cross-piece is joined on to the permanent magnet A. The end of this screw presses against a support, and the magnet being fixed *à charnières*, we can, by means of this screw, at will cause the prolonged poles of the permanent magnet to approach the armature or retire from it. This screw, again, is furnished with a counter stop-screw, so that the working of the apparatus may not gradually cause the upper coils to slip down.

We dwell upon these details because the adjustment of the apparatus depends on this regulator and this screw. G is a copper cross-piece fixed on to the body of the Morse, and supporting the magnet and the two upper coils. T is a bar of soft iron joining the cores of the electro-magnet. P is the soft iron, or magnetised armature.

a. The extended southern pole of the permanent magnet A. *b*. Extended northern pole of the permanent magnet A. *a'*. Southern pole of the lower electro-magnet. *b'*. Northern pole of the lower electro-magnet. M. Case of the Morse.

Before going any further we will mention some experiments made with our apparatus:—

Correct Transmission through 30,000 *Ohms.*—We have succeeded in obtaining signals absolutely correct, through a resistance of 20,000 ohms, by making use of a rheostat belonging to Messrs. Latimer-Clark, Muirhead, and Co., of London. The number of cells employed was twenty-five Leclanchés, of seven centimètres in height. Sensitizing the apparatus by a careful adjustment, we succeeded in getting correct signals through 30,000 ohms. Another experiment was to make the apparatus work through a resistance of 1,000 ohms, with one small Leclanché cell. These experiments were made with the object of proving the sensitiveness of the apparatus.

Transmission through a Non-Insulated Wire.—A rather curious experiment was made at the Brussels Zoological Gardens, before fully competent persons. A bare copper wire of one-and-a-quarter millimètres in diameter had been unwound upon the ground, in the grass, the shrubs, &c., for the distance of a kilomètre. The earth-plates were of copper, laid horizontally, and measuring forty-nine square décimètres. The battery used was a small Leclanché of ten cells. The signals were transmitted very regularly, and we think that no more conclusive proof can be given of the sensitiveness of the apparatus and the small electro-motive force which it requires. It should be observed that, the day before this experiment was made, and the whole time it was going on, a fine rain was falling, such as is always detrimental to electric telegraphy. From the series of facts which we have just enumerated we gather clearly that the apparatus works at much greater distances than the various receivers with springs at present in use, and that it has the advantage of needing a much smaller electro-motive force than any of them.

Duplex working without Condensers.—But the advantages we have just mentioned are secondary. The apparatus possesses others far more important, which we will proceed to analyse, and the demonstration of which will form a sequel to the description of our apparatus. The first of these advantages is that it allows not only simple transmission with reduced electro-motive force, but also duplex working without condensers. Of course, we are not speaking here of submarine lines, or of aerial lines of too great length. Our experiments seem to impose upon us a limit of from 400 to 500 kilomètres, according to the lines.

Automatic Control of Messages.—Another no less important advantage is the power of automatically controlling messages. For a commutator added at the two stations enables us to transform the lever of the receiver into a manipulator, so that the sender can follow with absolute certainty the reception of the message by his correspondent, which is undoubtedly the most complete control to be possibly obtained.

Rheostat.—The apparatus is furnished with a rheostat, but this rheostat, placed in a pigeon-hole drawer under the wooden pedestal of the Morse, is composed of only three coils of very fine wire. Each of these coils is of a different resisting power; they are marked respectively—*very dry weather*, *ordinary weather*, and *thaw or bad weather*. This set of coils, or rather this rheostat thus composed, is arranged according to a proportion which we shall speak of shortly, and this proportion is fixed in accordance with a law based on the resistance, or part of the resistance, of the coils of the electro-magnets and of the line. By this method of construction of the rheostat, and by the differential adjustment of the apparatus, we have succeeded in

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completely overcoming the difficulty in the working of rheostats. This working was the stumbling-block in the way of duplex systems without condensers.

Establishment of a Station.—The method of establishment of a station is shown in Fig. 4. In this figure we see the two stations in the same direction—that is to say, that the permanent magnets A and A′ have their southern pole at *a*, *a*′, and their northern at *b*, *b*′. R and R′ are the receivers, M and M′ are the sending-keys, P and P′ are the batteries, Q and Q′ are the rheostats, *l* and *l*′ are the commutators, F and F′ are the commutators of the three different resistances, which we have indicated by *very dry weather*, *ordinary weather*, *thaw or bad weather*. The post *c*, in co-relation with the commutator I, served for the bifurcation of the current, indicated at *l*. The post *m* is that of the *massif*. In the ordinary position this is insulated; in case of control, it is set in communication with the line bifurcating at *l*. The post *b* is in communication with the earth. The post + is the positive of the battery, L is the line, and *r* the rheostat.

Simple Transmission.—Figure 4 shows the circulation of the current when one of the two stations alone is working. The station A sends out the current; it follows *a*, *d*, bifurcates at *l*, and one part follows *f*, *h*, *i*, *i*′, *h*′, *f*′, *l*′, and enters the earth by *d*′, *b*′, and T′. The other part of the current which bifurcates at *l* follows at *l*, *g*, *e*, *m*, passes along the rheostat Q, and enters the earth. No bifurcation can take place at *l*′, because the resistance of the left-hand coils of the apparatus R′ and of its rheostat Q′ is far greater than that of the direct communication *l*′, *d*′, *b*′, T′.

It is well known that there exists a correlation between the resistance of the rheostat Q and the resistance of the line and of the coils of the apparatus. The rheostat is constructed in the following manner. In short lines (100 kilomètres) the best resistance to be given to the four united coils seems to be a resistance equal to that of the line. In order to make the rheostat of stations under these conditions we must give it (as *ordinary weather*) a resistance of 100 kilomètres, plus a resistance of two coils (50 kilomètres), in all 150 kilomètres. The rheostat for bad weather must be diminished by one-fourth, that is, in the present instance, to about 115 kilomètres, the resistance of the line being diminished at the point of bifurcation *l* of the sending station; on the contrary, the rheostat for *very dry weather* must be increased by one-fourth, that is to say to 185 or 190 kilomètres, the resistance of the line being increased. At 200 kilomètres we may follow the same movements, observing that the starting point is based on the line in the construction of coils, and on both in the construction of rheostats. At this distance there will no longer be any need to modify the resistance of the coils of the apparatus; and it will thus be only the resistance of the line which which will change the construction of the rheostats in accordance with principles indicated above. Having observed the course of the current, we may remark that the electro-magnet E of the receiver R has been affected so as to determine, at its own extremities, two poles of the same kind.

As for the cores of the permanent magnet A, they undergo the same influence. Therefore the armature P remains stationary. At the receiving station the current, following the course indicated by the arrow, polarises *a*′ at *b*′, and determines the magnetizing of the electro-magnet E at *b*″. The armature P′ has thus been set in motion, although we have formed only weak electro-magnets.

Duplex Transmission.—Figure 4 supposes the simultaneous despatch of the current from each station (positive current on both sides). The current of the battery P gives rise to two derived currents, one at *l*, *f*, *h*, *i*, the other at *l*, *g*, *e*, *m*, Q, T. The current of battery P′ is derived in the same manner. The two derived currents, *l*, *f*, *h*, *i*, and *l*′, *f*′, *h*′, *i*′, circulating in opposite directions, neutralise one another, and no current traverses the line, nor the right-hand coils of each instrument. In this case the two instruments are influenced by their local battery, following *l*, *g*, *e*, *m*, Q, T, and *l*′, *g*′, *e*′, *m*′, Q′, T′, until the opposite station raises its manipulator. At this moment the current resumes the circulation indicated in Figure 6.

Circulation of the Current when the Bifurcation is insulated.—Figure 8 shows the moment, short, it is true, but still appreciable, during which the manipulator of Station A′ insulates the bifurcation *l*′.

In this case the current sent out by battery P traverses the four coils of the receiving station; the development of magnetic force seems to be increased, but is not really so, since, in this case, the rheostat Q′ doubles the resistance of the circuit.

Automatic Control.—The automatic control which we have spoken of above may be easily understood. We have seen, in fact, that by the commutator the buttons and the lever of the receiver are transformed into a real automatic manipulator.

The phenomenon of retranscription will thus follow the same course as those which we have just described for the manipulator of the second station in the different cases studied.

ON A MODIFICATION OF MANCE'S METHOD OF MEASURING BATTERY RESISTANCE.

BY O. LODGE, D.SC.

The modification here suggested consists simply in using a galvanometer and condenser instead of a galvanometer alone, sc as to detect variations in difference of potential instead of variations in current.

By this change it is converted into a strictly *null* method. Moreover, it is now possible entirely to get rid of the effects of variations in the electromotive force of the battery, which are very annoying in any of the ordinary methods, and prevent accurate measure. This is accomplished by breaking the galvanometer-circuit the instant after the battery is short-circuited. Fig. 9 is a diagram of the connections for measuring the resistance of the battery *d* with the keys shown on a large scale; *m* partially short-circuits the battery when depressed; *n* closes the galvanometer and condenser circuit *unless* depressed. The two keys are electrically independent; but the stand of the upper one is balanced so as to rest partly on the spring of the lower one (which must be strong). On depressing the upper key, the first effect is to close the circuit marked *r* at the point *m*; the second, and immediately succeeding, effect is to break the circuit marked *g* at the point *n*. The same object would be accomplished more conveniently by a single double-contact key made on purpose, as shown in Fig. 12. The object of the double key is fully explained below. A B C D represents a box of resistance-coils; *a* and *b* are large and equal resistances; and *c* will be equal to *d*, the resistance of the battery, whenever the galvanometer-needle is unaffected by pressing down the keys.

Resistance-measurements in general.—Consider the arrangement of six conductors joining four points (commonly known as the Wheatstone's bridge) as forming the edges of a tetrahedron or triangular pyramid (fig. 10). It is obvious, (1) that, as far as position is concerned, every conductor has precisely the same properties as any other, and (2) that any one conductor is adjacent to four of the others and opposite to the remaining one. Call the resistances of pairs of opposite ones *a* and *c*, *b* and *d*, *r* and *g*, and let electromotive forces be caused to act in any manner through any of them; then it can be shown that when $ac = bd$, *r* and *g* are "conjugate conductors," or that variations in the conductor *r* have no effect whatever on the current in *g*, and *vice versa*, no matter whether these variations are simple changes of resistance or the introduction of new electromotive force.

By ascertaining, then, whether the insertion or removal of batteries at *r* has any effect on a galvanometer at *g*, one can observe whether the relation $ac = bd$ is or is not fulfilled, and can change one of these resistances until it is. For the case when *a*, *b*, *c*, and *d* are simple metallic conductors, this is Wheatstone's method of comparing their resistances.

Again, reciprocally, when this relation is fulfilled, no change in *g* can affect the current through the battery in *r*; and, therefore, if this battery in *r* is the only electromotive force in action, a change in the resistance of *g* does not affect the current at all anywhere. Hence, a galvanometer in, say, *d* will show a constant deflection whether the resistance of *g* is 0 or ∞, whenever $ac = bd$; and this is Thomson's method of measuring the resistance of the galvanometer *d*.

Further, from what has been said, there is no objection to an existence of electromotive force in any or all of the conductors, *provided it remains constant*; for it will be equally possible to observe whether changes in *r* (of any sort) have any effect on the current in *g*; and if not, then $ac=bd$, as before. For the case when *d* is a battery of constant electromotive force, this is Mance's method of determining its resistance.

But it must now be observed that although changes in *r* may have no effect on the current in *g*, they must affect very essentially the current everywhere else, and therefore through the battery *d*. This battery ought, then, to preserve its electromotive force constant in spite of variations taking place in the strength of its current—a thing which no known battery is capable of doing. The electromotive force of every battery is really a function of the current it is producing and of the time it has lasted. In cells called *constant* the dependence of electromotive force on current and time is only slight; but in none does it disappear.

This fact that the current* and consequently, to some extent, the electromotive force of the battery are made to vary by the

* Professor Clerk Maxwell, in describing this method ('Electricity and Magnetism,' i. p. 411), says that "the current in the battery is not in any way interfered with during the operation;" but this must be a mistake.

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process of measuring its resistance, constitutes a great apparent defect of the method; but it is an irremediable defect, and is not peculiar to this particular method. It is in fact *impossible* to measure the resistance of a battery without varying the strength of the current passing through it, by any method founded, as all our methods are, on a measurement of current or of difference of potential. In other words, just as it is impossibe to measure any resistance whatever without the passage of a current through the resisting body, although it is quite easy to measure an electromotive force without any current circulating through the electromotor, so, although a current of constant strength is sufficient to give a measure of the resistance of a homogeneous conductor, such as a metallic wire of uniform material, or a homogeneous liquid, or anything else which contains no internal electromotive force, yet a variable strength of current is necessary to determine the resistance of an electromotor.

And the reason of this is apparent, viz., that the opposition experienced by a current in passing through an electromotor is of two kinds—one due to the proper *ohmic* resistance, the other due to the electromotive force; and with only one strength of current it is no more possible to tell how much of the opposition is resistance and how much is electromotive force, than it is to obtain the values of two unknown quantities from one equation. We may either take two measures of the strength of current and then eliminate one of the unknown quantities algebraically, or we may use a contrivance (like Mance's method) by which one of them (viz., electromotive force) is eliminated electrically; but two strengths of current are just as essential in the latter case as in the former, as also it is just as necessary that the two unknown quantities shall remain constant. It is possible that the resistance, as well as the electromotive force, of a battery does not accurately fulfil this condition, but that it varies to some extent with the current; in so far as it does this, however, it is not a definite thing, and is incapable of accurate measurement.

I have entered into this matter at some length because the slip in Maxwell is getting repeated in other books (*cf.* Cumming's admirable "Introduction to the Theory of Electricity," p. 162); and it is as well to get clear on the subject.

The difference of potential required to force a current of strength C through an electrometer of resistance R and internal electromotive force ϵ is $E = RC \pm \epsilon$.

Various methods may be applied to measure E and C; but no observation of a single value of E and C can determine R unless ϵ is known. Another observation with a different value of E and C must be made; and then ϵ can either be eliminated directly, or one can employ an indirect means of effecting its elimination, provided it remain constant. (If it does not remain constant, and if the law of its variation is unknown, no amount of experiments can eliminate it.) It is true that a single strength of current will suffice to determine R after ϵ is known; but in the determination of ϵ another and quite different strength of current (viz. zero) was employed.

A curious illustration of the impossibility of measuring the resistance of an electromotor by means of a constant current was noticed the other day in the physical laboratory at University College by Mr. H. F. Morley, who has found that the current produced by a certain form of gas-battery is, within very wide limits, almost independent of the resistance of its circuit. He endeavoured to measure the internal resistance of this battery by means of its own current, but found it quite impracticable.

Variation of the Electromotive Force of a Battery.—In what precise way the electromotive force of an ordinary cell depends on the current passing through it, and on the time that current has lasted, I am not aware of any experiments which afford us information; but a law like the following seems not improbable:—

$$E = Ae^{-\frac{pt}{R}} + B, \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where t is the time the cell has been in action through the resistance R; so that the rate of change of E is proportional to the excess of the strength of current it is producing over the minimum strength to which it will ultimately fall, or

$$\frac{dE}{dt} = -p\,\frac{E-B}{R}: \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

p is a number which may be constant, or it may be a function of the current or of t; but for a cell making any pretensions to constancy it must be small. A and B are constants such that $A + B$ is the initial, and B the final, value of E.

At any rate we may, I think, reasonably assume that E is not affected instantaneously, however much the resistance of the circuit R is changed, but that it takes a certain time to change its value appreciably; consequently, if we only change R for an instant of time and then restore it to its original value, E may be regarded as constant. It is this fact, I apprehend, which gives Mance's method its practical value, and renders it superior to the somewhat similar methods of Siemens and Thomson, because in it the change of resistance of r can be made very rapidly without disturbing the galvanometer, and need only last a few seconds. The shortest time, however, is sufficient for some variation to take place in the battery; and accordingly a kick of the needle is usually observed, like that produced by an extra current, which is very annoying. The modification which I have to propose, however, renders possible so great a virtual diminution of the period of contact that this disappears.

[TO BE CONTINUED.]

THE IMPROVED HUGHES TELEGRAPH APPARATUS OF A. E. GRANFELD, VIENNA.*

This apparatus was patented in Austria on September 19th, 1874, and subjected to a trial of three weeks in January and February, 1878, on the line between Vienna and Prague. For this purpose there were applied ten Hughes apparatus, and furnished with the improvements by the mechanician, O. Schäffler, of Vienna. The distributor connecting the telegraph lines with the single working apparatus resembles that employed by Meyer, except that it still requires a spring and a contact ring, containing n contacts only, for the purpose of closing a local battery circuit which at the proper time releases each of the n working parts. But this distributor may be so employed as an improvement to any ordinary Hughes that it in no way prevents its employment as a type-writer. Hence the main apparatus thus formed may be used as a Hughes as long as it is able as such to control the number of messages required; but, if the press of business becomes so great, it can be employed as a multiplex instrument, and for this purpose there is required merely an alteration in the connections. With the multiplex arrangement the movable part of the main apparatus has only to touch the finger, as each working apparatus possesses its own special adjustments, and has no mechanical connection with the main apparatus, and can accordingly be set up in any convenient part of the office. Hence, whereas in Meyer's system, for instance, the unevenly distributed work of the Morse, worked by one and the same mechanism, must render it extremely difficult to maintain the synchronism of the two systems working together, such disturbing influences are here avoided, and the two main apparatuses will work at least as well together as two of the Hughes', while at the same time still isochronic, as the current falls by the break of contact, and the type cylinder is reversed once only with every revolution. This is effected by means of a rectifying current. It can yet scarcely be hoped that by the application of two sychronous machines, if these (like those of Meyer and Hughes) have also to perform telegraph work, all the currents will ever be practically utilised, which, judging from present experience, it might be possible to send in a given time. According to Granfeld, these amount to 166 per second.

As a writer, Granfeld employs that used by Meyer in his recording and in his duplex systems, viz., that, writing like the ordinary recorder, the writing itself is produced on a tape so that each letter, &c., forms a line by itself. But, if each written line were to be continuously worked with the main apparatus without synchronism, the ends of the lines would not fall parallel with the margin of the slips; in fact, elementary signs belonging to one and the same line would often be transferred to two different lines. But if, in each of the n working apparatus, the revolving axle is set in motion just before the beginning of each interval during which it is being connected with the telegraph line by the distributor, it may then be kept long enough in a nearly uniform motion to enable the writer to effect a complete revolution. Care must also be taken that this revolution be never completed until the index of the distributor has finished its course over the n part of the contact plate of the distributor belonging to this working apparatus. The writing will then become regular, each forming a separate line, and yet the $2n$ working apparatus will not require to run synchronously with the two main instruments. Granfeld releases each working apparatus as soon as the finger passes the middle of the n part of the contact plate belonging to the working apparatus previously referred to. He, moreover, choses the transitions in the working apparatus in such a way that, when working synchronously with the two main instruments, it completes the revolution of the contact plate and comes to a stop as soon as the index reaches the middle of the n part of the contact plate belong to the working apparatus to be hereafter described.

[TO BE CONTINUED.]

* Translated from Dr. Zetzsche's Articles in 'Ding. Poly.'

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THE PROSPECTIVE PERMANENCY OF SUBMARINE CABLES.

At the recent general meeting of the Globe Telegraph and Trust Company (Limited), which we reported in our last issue, the Chairman touched upon a point which is of the greatest moment to shareholders in submarine telegraph enterprise, and which is of scarcely less interest to electricians and telegraph engineers. "I know there are gentlemen present," said Mr. Pender, "who believe that an Atlantic cable may be made to live for all time; I only wish that proposition could be fairly established—because if it were fairly established the advantage to telegraph engineers would be something enormous. . . . I trust that science will be able to effect what we hope!"

Whilst disclaiming any pretension of adequately treating, within the limits of a single article, so large a question as that involved in the accumulated evidence bearing upon the permanency of cables, we may briefly consider, at least suggestively, whether there are any conditions under which we may reasonably conclude that a cable would remain electrically perfect for an indefinite period; and, if so, whether these conditions—mechanical, electrical, and chemical—are practically attainable with any degree of certainty, or approachable under a conjunction of favourable circumstances. It is now seventeen years since the Joint Committees of the Board of Trade and the Atlantic Telegraph Company recorded their opinion, based upon the voluminous evidence laid before them, that "the failures of the existing submarine lines had been due to causes which might have been guarded against." We have to inquire whether the same verdict is applicable, in some less degree, to recent failures—one of which, that of the 1866 Atlantic cable, would appear to be as final as that of the 1857 cable, albeit it was long deferred, and is happily less overwhelmingly disastrous than the first venture of the Atlantic Company?

In regard to the first point which suggests itself, that of the chemical stability of the insulating material when submerged, we think every electrician will endorse Mr. Pender's opinion that the gutta-percha of the 1866 cable is now as perfect as on the day it was first put down. We know that in air, more especially when exposed also to light, gutta-percha absorbs oxygen and becomes partly converted into a brittle resinous substance, soluble in alcohol and in dilute alkaline solutions. Only one other chemical change, so far as we are aware, has been noticed in this material—viz., that occurring in ground containing tanno-gallic acid from oak trees or posts, and due probably to the action of a minute fungus. Signs of electrolysis, by the action of a high electromotive force, may, no doubt, be exhibited; but, even in the case of a thinly-coated wire, no appreciable alteration either of the copper or of the insulator can be produced through it, under the conditions of practice, excepting at those points where the continuity of the gutta-percha is more or less defective, or, in other words, where "faults" may be detected. In regard to submerged gutta-percha, we have the evidence of Sir S. Canning that the material was found quite perfect when the Dover-Calais cable, laid in 1851, was raised for repairs in 1859; the subsequent evidence has all been in the same direction, and we believe nothing has occurred to negative the opinion of Mr. Willoughby Smith that the gutta-percha of a submerged cable is, chemically, quite permanent, and "will last for ever."

The next point which occurs to us is the liability of the insulator to damage from the attacks of marine organisms. Amongst these, the *xylophaga*, a bivalve shell fish, and the shipworm, or *teredo*, have the worst reputation; for, although their ravages are mainly confined to the hemp which surrounds the core of cables, there is positive evidence that the former, at least, has in certain cases actually attacked the gutta-percha. We do not know of any case, however, where a failure of insulation has been traced to these organisms; their attacks being quite superficial, in the form of an elongated groove. Moreover, they do not appear to exist in any very great depth of water; so that in the case of deep-sea cables they may be altogether left out of account. The same applies also to the sun-fish, which, in one or two cases, is said to have damaged the insulation of cables by means of its caudal spines. Still, even in the case of deep-sea cables, some kind of permanent protective sheathing appears to be desirable; and we believe that special attention is now being given to this matter.

We may now consider the insulating material from an electrical point of view. And here we would most strongly insist upon the necessity, in the case of deep-sea cables at least, of the most scrupulous care to prevent any fault, however minute or incipient, being left in the cable at the period of its submersion. It may be said that scrupulous care is, at the present day, in most cases exercised; we would reply that in our opinion it might be augmented—though perhaps at the cost of considerable delay and additional expense. We would incur this delay and expense to secure an electrically faultless cable; and, with this object in view, we would if necessary augment the ratio of the weight of insulating material to that of copper, or otherwise increase the dielectric resistance. Probably we cannot do better, under this head, than give a suggestive quotation from the Report, dated the 21st February, 1876, of Sir W. Thomson and Mr. F. J. Bramwell to the directors of the Direct United States Cable Company (Limited).

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After observing that the tests applied proved the great care that had been taken in the manufacture of the cable, they state that "The laying of the cable was also conducted with the greatest care, so as to avoid leaving in it any discoverable fault of insulation, however minute. On these occasions, while engaged in the deep-sea portion of the cable, its egress was stopped on account of faults, which were very minute; two of these were hauled back and cut out on board the ship, while the third was cut out and left at the bottom. The two which were brought back have been marked with two notches and three notches respectively; these we have carefully examined, and we find in each case the fault consists of a single exceedingly small airhole through the gutta-percha—a hole so small as to be barely visible to the naked eye. On cutting down through the gutta-percha to the copper core, we found the wires composing it to be altogether undisturbed and unchanged, and to be perfectly central in the gutta-percha, thus showing conclusively that the holes were not produced mechanically by puncturing inflicted by the wires of the copper core itself. There can be no doubt from their appearance but that the holes were produced in the course of manufacture by minute quantities of air, which had been left in the compound before applying the gutta-percha."

It is easy, in the light of past experience, to trace the consequences of submerging a cable with a few even of such minute faults or weak places. After a time, the worst of these becomes considerably enlarged, the leakage through it acting to some extent as a protection to the others; the cable is raised and this fault cut out, and subsequently the next in magnitude behaves in the same way. And, though we have heard a great deal as to the certainty with which deep-sea cables can be picked up and repaired, there is, unfortunately, a considerable amount of evidence in the other direction.

Other important points are the nature of the sea-bottom and the direction and character of the surface currents. Whilst we admit that the safest locality for an electrically perfect cable is undoubtedly a level *deep* sea bottom, we can but take a gloomy view of the chances of permanency in the case of a cable laid on a sea bottom like that which prevails on some portion of the route of the direct Lisbon cable. Here we can but look wistfully towards the hydrogaphers and nautical men who have already rendered signal service in deep-sea telegraphy. Can they, by the exercise of the same amount of scrupulous care as is demanded of the electrician, guard us against the dangers of the rugged deep, and avoid the graceful but deadly festooning of the cable from edge to edge of the rocky chasms, of which the existence in some cases can scarcely be doubted? We can only suggest that—in the absence of surface currents, and of any necessity for "laying-to"—the most suitable cable for such a rough bed would clearly appear to be one having a specific gravity but little superior to that of water, any iron sheathing being a source of weakness rather than strength. And, in relation to this sheathing, we would submit as a logical conclusion that, in the case of an electrically-*perfect* cable, laid over a level *deep*-sea bottom, any mechanical strength above what is required to secure safety in handling and laying the cable would be superfluous, and, probably, also detrimental. And, believing, as we do, that an electrically-perfect cable is practically obtainable, we look forward to the period when the raising and repairing of deep-sea cables may be regarded as a contingency no longer to be provided for—a remedy the means for which has often brought about the disease it was to cure.

Far different is it in the case of shore-ends, and in that of cables to be laid in shallow water and even in moderate depths. Here, we admit, experience is all in favour of heavy armour, and the necessity for raising and repairing cannot be avoided. Nor is it a necessity which, whilst our great submarine companies are provided with well-appointed repairing ships and skilled engineers, need be attended with any great anxiety or risk.

In conclusion—for our present space is limited—the conditions of absolute permanency in a cable appear to us to be summed up in two points, viz.:—1st. Perfect freedom from electrical faults; and, 2nd, a deep and level sea bottom. Both these conditions are, we think, practically attainable in the case of an Atlantic cable—excepting, of course, as regards the shore ends, the occasional failure of which would not endanger the deep-sea portion of the line. On some other routes, also, these conditions may, we have no doubt, be realised by the combined efforts of the electrician and the hydrographer. In shallow waters, a comparative permanency may be obtained through the adoption of the most effective means for raising and repairing the cable, one of the most important points being the protection and preservation of the iron sheathing. There remains, we fear, a considerable residue of cases where the second condition is unattainable, and where no aid is to be derived from this sheathing. Here the element of certainty appears to be entirely wanting, and a relative permanency is attainable only by a conjunction of fortunate accidents. Yet even here, under the almost prohibitive condition of a deep and rocky sea-bottom, there are important problems to be solved; and possibly much may be done by the association of the hydrographer and the telegraph engineer.

SCHWENDLER'S TANGENT GALVANOMETER,

A SIMPLE AND PRACTICAL INSTRUMENT FOR QUANTITATIVE ELECTRICAL MEASUREMENTS.

(Compiled by O. HENNEBERG, M.S.T.E., from Schwendler's 'Testing Instructions.')

Every telegraph engineer is well aware how necessary it is to have a convenient and simple instrument by which quantitative electrical measurements in any telegraph office can be executed with ease and despatch. A very practical instrument for this purpose, "The Tangent Galvanometer," combining cheapness and portability with sufficient accuracy of measurement, was constructed by Louis Schwendler, and has been introduced into the service of the Indian Telegraph Department. This instrument has proved so successful that its general adoption may be recommended to all telegraph administrations. In the following we will give a description of the instrument and its practical application.

Description of the Tangent Galvanometer.

The whole of the apparatus is contained in a little cubic wooden box of 6-inch sides. The sketch of the instrument is given in half natural size (Fig. 1), and Fig. 2 is a diagram showing the general plan of the instrument and its connections. The arrangement consists of:—

1. A tangent galvanometer wound with *two* coils, *one* coil consisting of a few convolutions of *thick* copper wire of 1 ohm resistance, and *one* coil consisting of a greater number of convolutions of *thin* copper wire of 100 ohms resistance.
2. Two sets of resistance coils, *one* set, consisting of 20 and 200 ohms, being in connection with the thick coil, and *one* set, of 1,000 and 2,000 ohms, being in connection with the thin coil.
3. A reverser, by means of which the test current may be reversed and the readings taken to the right and left-hand side.
4. Two stopper-holes, marked A and B, acting as keys for the thick and thin coil respectively.
5. Two terminals, marked S_1 and S_2, for fixing the leading wires.
6. For the purpose of measuring very strong currents, as is the case, for instance, when dealing with the currents generated by dynamo-electric machines, the brass ring of the galvanometer is cut into halves and connected up to a set of two "back terminals."

To the inside of the box is fixed a tabular statement, for the

purpose of measuring very exactly, and for controlling and checking the efficiency of the instrument :—

1.	Tangent galvanometer No. 5448.
2.	Resistance of thick coil 0·94 ohms.
3.	Resistance of thin coil 99·9 ohms.
4.	*All* resistances right at 20°C.
5.	A (thick coil only) a current of 1 weber = 86° deflection.
6.	B (thin coil only) a current of 0·01 weber = 60° deflection.
7.	Needle deflected at right angles swings 20 times before coming to rest.
8.	Needle without pointer swings 8 times in 10 seconds.
9.	Reduction coefficient $n = 0·11$.

In order that the strength of the currents passing through the coils may be as nearly as possible proportional to the tangents of the deflections, the magnet has a length of less than one-fifth of the diameter of the deflecting coil. The small magnetic needle carries a thin aluminium pointer fixed in right angle to the axis of the needle. In order that the needle after each deflection may come sooner to rest, the aluminium point carries small wind fans of the same metal. When closing the box the needle is taken off its pivot automatically.

Rules for the Use of the Instrument.

The needle should be quite free to swing, and the pointer should spin round as close as possible to the dial (to prevent parallax) without touching it. Both the ends of the pointer should point to zero, the axis of the pointer being a straight line. The same current should give equal deflections on opposite sides of the scale, which is the case when the index is at right angles with the magnetic axis of the needle.

These conditions being fulfilled, the coil of the instrument may be placed in the magnetic meridian by turning the instrument so as to bring the pointer to zero.

The needle once deflected to 90° (which is best to be done by quickly approaching a magnet and removing it very far at once) should give the required number of swings before coming to rest, and should always return to the zero point. Even slightly deflected, say to 2 or 3°, it should freely swing back to zero. Either loss of magnetism or injury of the pivot can have an influence upon the needle. Strong currents passing through the coils or rapid changes of temperature may have partly demagnetised the needle, which must then be remagnetised. The pivot may be rusty or the agate cup dirty. To remove any rust on the pivot a little chalk and oil is best to be used to carefully repolish it, while to clean the agate cup a piece of rag is tied round a well-pointed wooden stick and turned with gentle pressure inside the cup. The currents given in the memo. should give the proper deflections.

The sensibility of the galvanometer can be tested by joining up to it a carefully-prepared cell (Daniell, Minotto, or Meidinger's), which should give through 2,000 ohms, with the thin coil, a deflection of 5°, through the thick coil and 200 ohms not less than 4°, and through the thin coil and no external resistance about 60°. The resistance coils marked on the ebonite plate are *in* circuit when the corresponding stoppers are *out*. To make sure that the resistances of the instrument have not altered, a method for ascertaining this will be given further on.

One half of the scale is divided into degrees, the other half into tangents. In order to avoid dividing by (2) when taking positive and negative readings, the numbers worked on each side of the zero are not the *whole* tangents, but only *half* their values.

*All influencing magnets and coils ought to be removed from the neighbourhood of the instrument while tests are taken.**

[TO BE CONTINUED.]

* An explanation of the theory of this instrument, with a number of experiments specially made, will be given in the next portion of Mr. Henneberg's Paper, to which we would direct our readers special attention, hoping that they will not neglect to preserve this week's Supplement for reference to the figures.

EDISON'S LATEST INVENTIONS.

We are indebted to the New York *Daily Graphic* for the principal facts in the following account of Edison's latest work, and for the accompanying illustration. The aerophone and the megaphone, which are also described and illustrated in the *Graphic*, are not strictly of an electrical character; but we should not hesitate to give the description were not the pressure on our space this week so great. We are, therefore, somewhat reluctantly compelled to leave over this matter to a future number.—ED.

THE PERFECTED MICRO-TASIMETER INSTRUMENT USED AT THE SUN'S ECLIPSE.

Mr. Edison, speaking of the micro-tasimeter, says :—" It will measure any degree of heat that can be measured. If the sun's corona has any heat of its own, or possesses any heat-reflecting power, the tasimeter will measure it accurately. With the index divided into only fifty parts, it will measure 1-50,000 part of a degree Fahrenheit. With the index divided into a hundred parts it will measure 1-100,000 part of a degree, and do it with a single cell, and on a poor galvanometer, for I don't own a good one. There is only a single cell for a battery; but, if you increase the electric current, you increase the power indefinitely, and I don't think it too much to promise that ultimately it will be possible to measure the 1-500,000 part of a degree, and do it accurately. Why, if you increase the power it would throw the needle of a reflecting galvanometer entirely off the mirror. It bears just about the same relation to the thermopile that the latter did to the thermometer. See here, the heat of my hand moves the needle of this galvanometer, which is so poor that it was not at all sensitive in the presence of the thermopile." The illustration shows Mr. Edison's latest invention which has never before been satisfactorily described. In fact, as it now exists in its perfected form, it has never been described at all. In some respects the micro-tasimeter (minute-motion measure) is the most remarkable of all his discoveries, and is one which, had he invented nothing else, would have made him famous in the world of science. The central idea of the instrument is the peculiar susceptibility to electric currents shown by carbon when under pressure. This principle is Mr. Edison's most important discovery, and has been utilised in the carbon telephone, the microphone, and other instruments. A is a carbon button, fastened in a cell at the base of the truncated cone B, and insulated by platinum plates both above and below. Upon the centre of this button rests the hardened rubber slip C, held in position by the vertical screw D. Movement is given to the vertical screw by the worm-wheel E, which is in turn moved by the thumb screw F, which also causes the index finger G to travel about the graduated index face H. One hundred turns of the thumb screw causes one turn of the worm-wheel, which depresses the vertical screw one-tenth of an inch, and gives a corresponding pressure to the carbon button. One turn of the thumb-screw will give a pressure of 1-1,000 of an inch. The graduated face of the index is divided into 100 parts, and the motion of the steel finger over one degree will indicate a depression of 1-100,000 of an inch. This nicety of adjustment enables the pressure to any desired degree to be placed upon the carbon button, and to render it so much the more or less sensitive to the passage of electricity. It will be seen, too, that the instrument can be used for testing the compressibility of any substance and to determine the electrical conductivity of any substance under pressure. The instrument when in use is placed in the circuit between the battery cell I and the galvanometer K, the connection being made with the posts L L. The degree of heat is then shown by the movement of the needle over the face of the galvanometer. For ordinary observations a brass funnel, whose inner orifice is opposite the rubber slip, is used as a ray collector, and the heat of the hand held several inches from the funnel will cause the needle to move over several degrees while it is instantly sensitive to the presence of a lighted taper held ten feet away. The instrument has been in the hands of Professors Draper, Young, Langley, Newcombe, and others, for some time. They have made numerous tests and offered suggestions which have been of value in perfecting the mechanical details.

The instrument for the purposes of the tests made during the late solar eclipse was entirely insulated, so that it was not sensitive to any heat in the air or surrounding bodies. The extreme delicacy of the instrument made this difficult of accomplishment. The funnel was removed and the opening closed by a slide adjusted so nicely that a slit an inch long could be left on the line of the rubber slip, but so narrow that it could not be threaded by the finest hair. The whole was enclosed in a double case, the interstices between the boxes, about an inch all around, being filled with melting ice, the heat of which is uniform. The heat rays were then allowed to pass to the narrow slip and so to the rubber through a prism of rock salt. The experiments were looked forward to by scientific men with the greatest interest,

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and there is every reason to be proud of the success obtained. Similar experiments were made on the same day by different eclipse parties, among them that from the Smithsonian Institution, composed of Professor Newcombe, of Washington; Professor Young, of Princeton; Professor Langley, of the Alleghany Observatory, and others. According to telegraphic despatches the success was complete, but we must wait for further details before we can give the exact results.

STUDENTS' COLUMNS.

FRICTIONAL ELECTRICITY.—A NEW ELECTROSCOPE.

The form of electroscope now described was devised by me a few months ago.

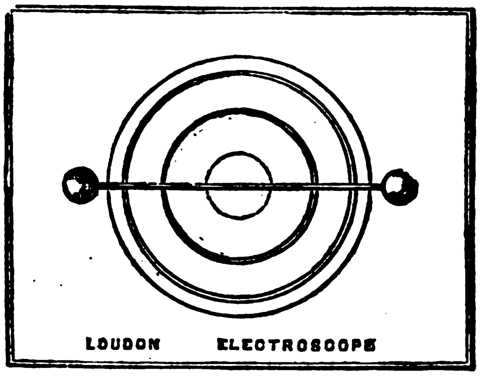
It seems remarkable that frictional electricity is not more studied. There is ample room in this field of electrical research for new discoveries.

The following is a brief outline of the construction of the instrument illustrated:—

The diagram is a plan of the electroscope. The stand of the instrument may be made of wood, brass, tin, or even stout card board. It is essential, however, that the stand of the instrument be weighty.

The arrangement looks neatest, as shown in the diagram, viz., circular. Fixed to the centre of the stand is a thick stick of sealing-wax, or a glass leg coated with shellac. This leg, as a matter of course, is at right angles to the plane of the stand of the electroscope. The length of this insulator need not be more than eight or ten inches. The dotted circle shown in the centre of the diagram, illustrates the position occupied by the insulated support. To the top of this support is affixed by sealing-wax a short pointed wire about one inch long.

The upper portion of this electroscope is made to rotate.



LOUDON ELECTROSCOPE

resting on the insulated leg, and supported by a "cap," is a rod of light, dry, and straight wood. This part of the electroscope need not be any stouter than an ordinary penholder, the object being to have it as light as possible, attached to the ends of the rod is a pair of round balls.

The introduction of balls on electroscopes is to me a new feature. I have never seen such an arrangement mentioned in any of the text-books that fall into the hands of electrical students. Therefore, I have thought fit to name the electroscope as seen in the diagram.

Having given a general outline of the construction of the instrument, I will deal with its

Action.

a. If a positive (+) glass rod be brought *near* one of the balls, the electricities on the rotating part of the electroscope immediately separate; the ball then moves towards the + rod. This at once induces polarity in the electroscope.

b. Carry in front of the ball the + rod, and you will cause the electroscope to rotate on its axis many times. This is caused by the — E following the + E.

c. Let the moving portion of the electroscope come into contact with the + rod, and a new state of things is the result. The electroscope now no longer follows the path described by the + rod, but appears at once stationary. If the + rod be moved at this moment from off the rotating piece of wood, and then brought near to one of the balls, the moving system goes backward. This is owing to the + rod combining with the — E that resided on the electroscope, consequently repulsion at once occurs.

d. Laying down the + rod when the motion of the electroscope is showing the dual force of electrity, and taking up a rod of brass, or any conducting substance, bringing the conductor near one of the balls of the electroscope, attraction is manifested.

e. Let the instrument return to a neutral state. Excite your rod and bring it near one of the balls. Keep the ball revolving after the + rod, taking care that the balls *never* come in contact with the rod. By so doing, the moving portion will soon show signs of independency to the + glass rod. When the electroscope ceases to follow after the rod at this stage of action, on bringing the rod *near* one of the balls at the moment, they wander backwards as before, yet contact has never taken place.

A dielectric may be suspended and carried in front of the rotating balls. The same phenomena in this case takes place. Induction here turns a corner, or is exerted in a curved line, which cannot be accounted for in any other way than supposing the air between the glass rod, and the balls serve as a medium for the transmission of the rod's electrical action.

With this instruent Government teachers could illustrate a great part of the frictional branch of this science at little cost.

This instrument claims to show:—

1st. Electric polarity. (See *a* and *b*.)

2nd. Dual force of electricity, shown by the backward motion of the balls. (See *c*.)

3rd. A tendency for the fluids to recombine, or a + body following after a neutral one. (See *d*.)

4th. Electric induction manifested, showing similar results to contact. (See *e*.)

This instrument also serves as a ladder in understanding the theory of lightning conductors. By inserting a fine-pointed wire into each ball, letting the end of such point freely into the air, the above experiments are rendered impossible.

Heworth. RALPH LOUDON.

ANGLO-AMERICAN TELEGRAPH COMPANY, LIMITED.

Proceedings of ordinary general half-yearly meeting of the Anglo-American Telegraph Company (Limited), at the Cannon-street Hotel, 2nd of August, 1878, the Right Hon. Viscount Monck in the chair.

The SECRETARY (Mr. John Grant) read the notice convening the meeting, and the minutes of the last general meeting.

The CHAIRMAN: Then, gentlemen, I presume you will take the Report as read, and it becomes my duty, in conformity with the practice on such occasions, to propose to you that the Report of the Directors be received and adopted, and, in doing so, to endeavour, as briefly as I can, to give you, as our constituents, an account of our proceedings during the last half-year. Gentlemen, in reference to that subject, the principal topics, in fact the only topics which are of very much interest, are the state of your property as regards its efficiency and preservation, the amount of income which we have received during the half-year, and the moneys which we have been obliged to pay for the receipt of that income. Well, gentlemen, with respect to the condition of the cables, one of the first paragraphs in the Report anticipates all that I have got to tell you on that subject. The three cables with which we have been operating during the past two years are in perfect order and doing our work as well as it could possibly be done. With regard to the receipts, you will see that the receipts of the last half-year are somewhat less than those of the preceding half-year; but, on the other hand, they are very large receipts in comparison with what we have had in previous half-years. The second half of the financial year has always, according to our experience, been the better half; and, therefore, the 260,989*l*. receipts of the past half-year, we may confidently expect, will be increased during the approaching half-year. Now, gentlemen, I think that is a very encouraging state of things, considering the circumstances under which this income has been received. In the first instance, though we have happily got rid of hostile competition—and I see my friend opposite, who is now a very friendly member of our company instead of being chairman of an opponent company—and we are working on the most perfectly amicable terms, still we have been obliged, as you all know, to give up a certain share of our receipts to our friends and partners, the Direct Cable Company. Well, notwithstanding that, we are taking as our share what enables us to pay a substantially good dividend on our whole stock. Well, gentlemen, I am not going to weary you by repeating what you have heard for the last three or four years at every meeting of shareholders in industrial enterprises which has been held in the city of London. I will not weary you by dilating on the depression of trade, that has had an injurious effect on our enterprise, as well as that of all other industrial enterprises in the country. We may hope, I trust, that some of the causes, at all events, which caused that depression have been happily removed—the dread of war, and that sort of thing; and we may hope that the pressure of that depression will, to a certain extent, before long cease, and, I hope, soon entirely disappear. And I think it is almost a matter of certainty that if we have been enabled, with the effect of that depression operating upon us, to take so good an income as we have done during last year, we shall be enabled, when that depression ceases, largely to increase our receipts. Gentlemen, I think the state of our receipts, even under the depressing circumstances to which I have alluded, bears out what I have always stated as my opinion in our dealings with the Direct Cable Company before we came to agreement. I mean that I always maintained that there was room enough in the Atlantic for both of us to make a good profit. I believe that the longer we live and the more we continue to carry on our trade, the more convinced we shall become of that fact. Therefore, I think there is no cause for depression with regard to the future. I believe we have seen the worst we are likely to meet with, and that in the future we shall improve our prospects and improve our receipts. Well, gentlemen, so much with regard to the income of our Company. Now, with regard to the cost to which we have been put. You will find on a reference to the report that the cost of working the Company for the past half-year has been 44,265*l*. Now, that includes an item of 11,000*l*. for the repair of cables, and we contributed, towards the repair of cables, that

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sum from the income of the company. And, looking to the large capital that we possess, and the extent of the traffic that we carry on, I don't think that you will say that 33,000*l.* for the half-year is too much for the net cost of carrying on our business. Gentlemen, on a former occasion I ventured to warn you that we were not likely to have any large diminution in the expenses of the company, and I put it on the ground which I still maintain, that your directors have reduced the actual expenditure on the working of the company to the lowest point compatible with efficiency; and, besides that, that as your servants grow older in your service, and in conformity with the usage of all industrial companies and employers of labour generally, you will find it necessary and desirable to increase their pay; so that I rather indicated in my remarks on former occasions that you should look for a trifling increase rather than a diminution in the cost of the working of the company. Well, gentlemen, I have been agreeably surprised; because, if you compare the cost of the working expenses for this half-year with that of the corresponding half last year, you will find that there is a certain reduction in the amount; but that is to be attributed not really to any real reduction in the cost of working, but to accidental circumstances. There are buildings of different kinds connected with your undertaking at the termini in Ireland and America, and those buildings require—especially in America—constant repair and renewal. Well, those expenses apparently increase the half-year's expenditure; but they do not really imply a continuous increase of the outlay. Gentlemen, so much with regard to the income and expenditure, which, I think you will agree with me, on the whole, is in a satisfactory condition. Well, the only other topic to which I think it necessary to allude on the present occasion is noticed, but noticed only partially, in the report; and it is noticed partially because the information which would enable us to deal fully with it has only reached our hands, and that only to a certain extent, within the last few days, since the report was printed—I mean with regard to the repairing expedition which we sent out to endeavour to take up the cable of 1866. Now, gentlemen, in talking of this subject, I think I may recall to your recollection that, in addressing you on the same matter upon former occasions, I never was very sanguine in my hopes that we should be able to succeed in this matter. I always said that the attempt to take up this cable was a thing that we owed not only to ourselves and our own shareholders, but to the cause of telegraphy generally, in order, if possible, to ascertain the probable duration of deep-sea cables. Well, gentlemen, we have done all that we could. We fitted out an expedition this year—and here I may say, parenthetically, that I think great credit is due to the public spirit of the Telegraph Construction Company, who voluntarily offered us, and fulfilled their offer, to pay half the expense of the expedition. Well, gentlemen, since the report has been in type, the ships have come back, and we have received (I only saw it last night) a partial or preliminary report from our engineer, who went in charge of the expedition and who went as consulting engineer—Mr. Hocking, who is well known to all gentlemen here as a very able man; and I regret to say that Mr. Hocking's report, founded on the experience he has had during the last two months, is decidedly opposed to the idea that we can recover that cable for practical purposes. Well, gentlemen, I don't think, notwithstanding that, that there is any cause at all to be disheartened with reference to it. In the first instance, our cable power—the cable power which we have in working order, together with that of our allies, the Direct United States Cable Company—is, happily, sufficient for the transmission of the traffic. We are doing a good traffic, and doing it very efficiently, and there is no reason to suppose that the cables we have are not fully sufficient for the traffic we have to carry; and, in addition, the cables through which we are now operating of 1873 and 1874, the two last laid down, are of superior construction to those which were previously laid, and they are better defended with outside covering than former cables, and, therefore, it may be expected they will last longer than the others. Well, there is another consideration, namely, that though we cannot pick up these cables and repair them for the purposes of traffic, yet in those old cables we can still recover a large amount of valuable property which is laid down, and utilise it for other purposes; so that, on the whole, with reference to the outlay, I do not think there is much cause for being disheartened. But, gentlemen, whatever other effect it may have on your mind, it will convince you of the soundness of the policy which has been adopted by your directors with reference to these questions—that is, laying by a good reserve, so as to give permanence to your property, and to enable you whenever the time arrives and the necessity arises to go into the market with the price of your cable in your pockets or at your bankers', and pay for it with ready money. You are all men of business, and you know the difference between credit and ready money, and my opinion is we should never rest until we have at our bankers', or invested in good security, a sufficient sum of money to replace our cables. You will see, gentlemen, that there is a separate account given in the report of the state of your renewal fund. You will see at present it amounts to 275,000*l.*; and, if we go on with our receipts as we have hitherto done, in the course of a short time we shall be in the position I have just explained to you, and be able to go into the market when we want a cable with the money in our pockets to pay for it. Well, gentlemen, I don't think there is any other matter needful to trouble you with on the present occasion. I assure you that your directors endeavour by the utmost assiduity and attention to your business to carry on your traffic with success and efficiency. We have the assistance, as you all know, of the gentleman who sits near me, without whom our efforts would be unavailing. I beg to move, therefore, in conclusion, that the report of the directors and accompanying statement of account to the 30th June now submitted to this meeting be and the same are hereby received and adopted.

Mr. William Barber: I have great pleasure in seconding that.

Mr. Prust: May I ask with regard to the 110,000*l.* we have in Consols whether it is money value or the price of the stocks at which it was last taken? and one or two other questions I should also like to ask. With regard to the cash in hand of the Renewal Fund, we have 67,956*l.* of that not invested, and not really producing anything [hear, hear]. And then, again, I see we have an account with those respectable bankers, Barclay, Bevan, and Co. We have fifty odd thousand there, a very handsome balance, to our credit doing nothing, and I have no doubt they look upon us as very good customers indeed [hear, hear]. I am not finding fault with them getting all they can. Then, with regard to Consols, I am looking upon the board as knowing that the price of Consols are now higher than they have been for the last fourteen years, and when we have commerce coming round again, and money is wanted for commercial purposes, Consols will necessarily be sold, and, indeed, are being sold now. The average price for the last fourteen years has been 92, and that is, no doubt, the price they will come to again. I beg to call your attention to the fact that they only yield us 3 per cent., while we could have securities to yield 4 per cent. as good as the Bank of England. Debentures in the best railways in England pay 4 per cent., and then, again, the 4½ per cent. funded lives of America, generally speaking, are as good as Consols, and will yield us at least 4½ per cent. I am sure you will consider this an important matter, when you consider the enormous expense that is charged with the gross take that is yielded by it. If we could reduce our expenses by earning another 1 per cent. of dividend in this way, it would be a good thing, you will admit. For instance, the 110,000*l.* of Consols, provided they were earning 1 per cent. more, would bring us in another 1,000*l.* a year. Then the 67,000*l.* invested at 4 per cent. would give 2,500*l.*, and I should look on 3,000*l.* or 4,000*l.* extra a year as something in the way of improvement. Therefore, I particularly wish to call your attention to the fact that we might have this increase. Of course, we must, above all things, have good and first-class security; but I consider we might have a larger dividend on as good a security as Consols, and you could always release them in a day. With regard to the expenditure on the amount of our gross take, I need hardly say that it is very large. I do not see really that you can reduce your expenses; no doubt, you pay a very considerable staff, and must have, as you have always, first-class scientific men connected with you. But I do hope, if it is possible, that you will turn your serious attention to the matter, and see if you can reduce that amount by some means or another, and, look to the developement of further interest, for I think there is one per cent. more might be got at least for the deferred shareholders. I put it to your judgment for your serious consideration.

Mr. William Newton: I should like to ask a question in reference to the renewal fund. I think, sir, it was an instruction to the auditors last year that they should state the amount of money invested in cables, to show that we have a considerable amount of revenue put to capital, and I think that it should be known that our cable is really worth what it is represented to be in the market. I should also like to draw your attention to the figures, where you state the revenue account, where you state the working expenses at 27,000*l.* If you contrast your reports with those of the Eastern Telegraph Company and of the Eastern Extension, and the Western Brazilian, you will find they give very full details of the expenses [hear, hear]. I think you might very properly show where the money goes.

Mr. Griffiths: The previous speaker has spoken with reference to the economy of working the plant and undertaking. I would venture to mention a question with reference to the economy of working our telegraphs themselves. We all know that recently a great discovery has been made, and messages can be sent both ways over the same cable at the same time. Is it not possible that, by adopting that invention, you can make one cable do very much more than it has done hitherto, and, if so, is it necessary we should have such a large number of cables? The second question which I wish to put is with reference to the length of cable in stock. That is valued at 84,000*l.*, I believe. I was looking over the old reports of the company, and I find that one of the reasons for laying down the last cable was that we had such a large quantity of cable in stock which might be deteriorated; its insulating power might be injured by being kept unused. Now, if we have a large amount of cable in stock, which is liable to the same danger as the cable which was mentioned on the last occasion, I think it is but poor economy that we should have a renewal fund of that description. I quite agree as to the remarks made as to the interest we may make. I think we may make much more interest than 3 per cent., and, though I am in favour certainly of keeping our working plant in proper order, it does seem to me that we are somewhat confiscating the interests of the deferred shareholders, who hold upwards of two-sevenths of the capital, and they certainly have some claim to consideration [hear, hear]. A third question which I have to raise is as to the injury which the cables have sustained. In your very interesting speech you omitted to tell us the cause of the injuries to this cable. I have had the opportunity of inspecting the Cuba Telegraph Cables, and I find there the injuries arose from two causes; firstly, from the bad state in which they were laid. The sailors were either idle or drunk, or for some other reason the cable was badly paid out; it was deposited in coils, and the consequence was that it soon broke. I do not know whether we are indebted to the persons who laid our cables for some of these injuries, or whether these injuries have arisen from the action of salt water. I was looking over some works on electricity, and I found that before the telegraphs to America were laid down a celebrated French authority (Monsieur . . . .), suggested that the action of salt water would be very injurious to the external covering, and that after a time there was little doubt that the covering would be corroded. He suggested a plan that it should be covered with zinc—that the iron should be passed through a solution of zinc, which would save the cable from the active action of salt water. He is, of course, a great authority, and if something in that direction had been adopted in time we might have saved these very valuable cables [hear, hear].

Mr. Jackson: There are two questions to which I should feel obliged for an answer, and I think it would be of great service to the shareholders. I feel that it is a tremendous fact that the original capital is absolutely gone with the 1865 and 1866 cables. I think as shareholders we are entitled to ask you whether the Board have given any serious consideration as to the consequences that arise out of the fact. It does appear that, in the face of such calamities, it would be well to hear from you whether there was any possibility of providing against such contingencies. Such a contingency is hardly the word. Such a fact would be the word we must expect. It is an enormous stake—something like 2,000,000*l.* of money is swept away; and I am endeavouring to ask if the directors have given every consideration to this question, and if they can tell us—if they are prepared to tell us—whether the cables at present are likely to last much longer; and whether the life of a cable would be six, eight, ten, or twenty years? That is a very important question for us. I quite agree with the remarks of gentlemen who have gone before, and who have referred to the different economies that might be effected in investments of money; but I should like to know what has been the amount of our reserve for twelve years?—not 20,000*l.* a year. Take it from 1866 to 1878, and divide the amount. I do not mean to say that it is a fair way of looking at it. But, supposing we have another cable, and supposing our revenue is trenched upon, the question for us is—can we feel assured that these cables are

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being so protected that we may reckon on the life of them for something more than six, eight, or ten years? I think that is a question we all wish to know, and the thing is whether the directors have considered the propriety of revising the tariff. It is a very important matter, and if we do not do it it may be done from the other side. Americans have done many things. If we look at their invention of the telephone and other matters, I think, under the circumstances, it is an advisable question with us to know whether you have looked this in the face and determined whether a 3s. tariff might be adopted. These are the two questions, and I hope in your reply you will kindly give us some definite information which may be some assurance to us, but I have every confidence in the capability and the judgment shown by the directors; but, at the same time, I should like an answer to these questions.

A SHAREHOLDER: Will you kindly tell us approximately the costs of the expedition, now returned, which we shall have to meet?

ANOTHER SHAREHOLDER: The questions these gentlemen have raised excite great interest in the meeting, and will no doubt receive great attention at your hands, but there was also another question in regard to our making the best of our investments. I, too, think a great deal of our Board, and have a high opinion of you, and I can see no reason really why we should be content with the return we get from Consols when we could invest with safety in other securities, and get a much larger return for our money. There are many securities on which you might invest on the best terms, and get better interest than we do now, and I feel almost certain when you come to realise your securities you would be easily able to do so. We know the colonies are from time to time in the borrowing market; and their loans are easily taken up by large firms. We generally pay very nearly the minimum price—four or four-and-a-half per cent. is the rule, I think, for loans of that sort, so that we will assume that you will place your 100,000*l.* at the minimum price, getting for that four and four-and-a-half per cent., and if you want to realise your security you will be easily able to do so. There is at the present moment a colonial loan in the market, and as in course of time the value of money rises the value of these loans will also rise. I would ask the directors to look to this suggestion. I think there is no reason why we should hold so large a sum of Consols as 110,000*l.* when we could invest the money with equal safety in good foreign loans.

Mr. PRUST: Referring to investments, I may mention that the Great Northern Railway are now issuing four per cent. Preference Stock, with the condition of being subject to the ordinary five per cent. shares. The other ordinary stock ten years hence will be equal to 140*l.* They are issuing their stock now at par; but I merely refer to that as indicating its solidity; and possibly there is a very large profit which may be made from it.

Mr. MORIARTY: Is there any portion of the cable brought to shore which may be seen at the office of the company, showing the state of depreciation during the time that it has been laid—since 1865 and 1866? I would also ask if you would kindly tell us whether in the year 1866, when the cable was only one year old and one year submerged, it was the opinion of Professor Thomson, and of men who understood the subject, that three ships were necessary to raise it in bights in order to bring it to the surface; and our experience positively proves that it can only be recovered by carefully lifting it, because when brought to the surface it broke. Of late years—these last two or three years—two ships only have been employed, and I have heard that in one case it was brought to the surface with only one bight. I think your board are men of great experience, and must know that it is an impossibility in a depth of two miles to bring one bight up in this manner. With regard to the reserve fund, I am very glad to find that there is a good one, because without a reserve we must look to debentures, and when once debentures come in the ordinary shares would go for nothing. I oppose the division of the shares into the two parts, like many others, because I say that it would lead to a division of interest, and as soon as we get two divisions of shareholders, one, of course, will cry out as being injured if there is a large reserve fund, without which our property would be literally worth nothing, because any day we may hear that the remaining three cables are defective; and there might be no renewal fund for another cable. With regard to the great stress laid on the improvement of cables, I do not believe in it. I believe the duration of strength has not been increased above ten per cent.—that is a breaking strain of ten per cent. has been increased to eleven or eleven-and-a-half per cent. The duration is not likely to be increased far greater than that.

The CHAIRMAN: I will endeavour, to the best of my ability, to answer as well as I can the several questions put to me. The first question put was by the gentleman who wanted to know whether the 110,364*l.* 16*s.* 10*d.* stated in the Report to be invested in Consols represented the present value, or the value at which it was purchased. I have the satisfaction of telling him, that it represents neither the one nor the other. It represents the money actually paid; and as Consols—and this in part may answer some other questions put to me—as Consols have risen very considerably since we purchased, I think the probability is that the rise in Consols would more than compensate if we sold out now for the low rate of interest we get for them. Still, at the same time, we believe in the beautiful simplicity of the Three per Cents.

A SHAREHOLDER: You should sell and take advantage of the rise.

The CHAIRMAN: An objection was taken to the amount uninvested of the renewal fund, and also to the large balance which appears at our bankers to our current account. Now, these two items are accounted for in two ways, which I am sure will at once commend themselves to the judgment of the gentleman who took the objection. In the first place, a large portion of our receipts come in in bills, which are placed to your credit at our bankers', but are not discounted immediately. In the next instance, and it is the real answer, this account is made up to the last day of the half-year. We have since that paid some thousands in dividends. One per cent. on the stocks would really absorb very nearly the whole of the money, or a large portion of the money that is stated here to be at our bankers', and uninvested, and we now proceed, as soon as we have the money at our bankers' to pay for it, to invest the balance of uninvested money on account of the renewal fund. We cannot invest until we get the money, and it must be put to our credit at our bankers' as soon as it comes in. That is the explanation. I am afraid if my friend, Mr. Bevan, were to look at his books and expect to find the 50,000*l.* to our credit, he would find himself very much mistaken if he thought he had that amount of our money to invest in his banking business. Then there was another question asked me with reference to a resolution which was proposed, but I beg to say not carried at the last meeting, proposed by my friend, Mr. Ford—viz., that the auditors should report to us the amount of money applied out of current income to what may be called the plant capital. Well, myself and my colleagues are always willing to oblige a shareholder if we can do it without inconvenience or injury to our concerns, and we have had the return made. I now hold it in my hand signed by the auditors, and it appears we have applied to that object, "that the total amount charged against revenue from May 1st, 1873, the date of the amalgamation of the Anglo-French and Newfoundland Companies, to June 30th, 1878, for renewal fund, new cable and extraordinary expenses, is 834,053*l.* 10*s.* 9*d.* That is the answer, Mr. Ford can see the paper if he likes to look at it, but that is the return given to us by the auditors in reply to Mr. Ford's resolution. Well, then, I was asked a question with regard to the duplex system. No doubt, that has been found a very valuable system, and increases the efficiency of the cable, I believe, to a very considerable extent; and I may inform the meeting that we are now having it applied to the cables, so that we may get additional work from it if necessary. I think one gentleman asked the probable cost of the expedition; of course, we cannot tell to a shilling, or to a hundred pounds, what it will come to, but our speculation is that our share will be from twelve to fourteen thousand pounds—something about that. Another question was asked with reference to the cause of the injury to the cable. Well, the cause of the injury of the cables is the rotting of the hemp covering which was put to protect the galvanised iron; and in reference to another question which was asked respecting the process for covering, I may say that our cables are galvanised, and I apprehend that the effect of galvanising is pretty much the same as the other covering would be.

Mr. GRIFFITHS: Same in character, but not in degree.

The CHAIRMAN: I am not sufficiently scientific to say, but it is intended to prevent the salt water affecting the iron covering. As far as we can understand, the real cause of the depreciation of these cables is the rotting of the hemp covering. If we could obtain any means by which that hemp covering could be effectually protected, that I believe would maintain the cables in good condition, and I may say that the construction of cables is not the business of this Company, but, of course, it is our object and our interest to obtain experiments in every way we can as to the best modes of constructing cables so as to ensure their durability. I may say I see some gentlemen representing the Telegraph Construction Company in the room, and I am sure they will corroborate what I say. They, for the last year, ever since the expedition of 1877 came home, have been occupied in various experiments to ascertain what is the best mode of protecting a cable, and whether any change in the construction of the cable would enable us to obtain solidity and durability from it. As far as the practical question of trying experiments, and bringing all we can to bear on the subject is concerned, we are having the experiments made by gentlemen who have been long engaged in the construction of cables, who have been engaged in laying them down, and who understand all about them, and will give us the benefit of their experience as they obtain it. Then there was a question asked with regard to the tariff. Well, gentlemen, I do not wish to commit myself irrecoverably or finally to three shillings, as the only tariff we can have, but I understand you support the opinion I have expressed that, if communications between this country and America become as large as they were some eight or nine years ago, a three shilling tariff will enable us to pay you the dividend already indicated, and to lay by a sufficient sum to the reserve fund. Another gentleman asked where he could see a specimen of the cable. I believe we have a specimen of the cable at the office, and any shareholder who calls there may see it. Then, with regard to the last gentleman who spoke—Mr. Moriarty, I think—in reference to the objections he made that in 1866 three ships were supposed to be required to take up a cable, all I can say is that he has large experience, which I have not, but we had the advice of those who have laid down all the Atlantic cables except one—who have laid down almost all the deep sea cables in the world—and they considered two ships sufficient for the purpose, and, what is more to us, they backed their opinion by offering to pay half the cost of the expedition; and having arranged that they would pay a portion of the expense of the expedition, it is not very likely they would have sent out what they considered an inefficient expedition to undertake the work. That is the only answer I have to give to it.

Mr. NEWTON: You did not tell us about the question to which I drew your attention as to the accounts.

The CHAIRMAN: I think there is an immense inconvenience in changing the form of accounts. It prevents the shareholder from being able to compare one half-year with another. I honestly confess that I do not see that any great good would arise from a change. Another thing is that it is desirable to hold the meetings as soon after the conclusion of the half-year as possible, which renders it almost impossible to give those minute details.

Mr. NEWTON: The "Direct" do it [cries of "Time"].

The CHAIRMAN: We get home our accounts from Newfoundland by telegraph. You will find, if you look into the Eastern Extension—and I am a member of the board—that their accounts are made in the form alluded to, but you will find that their meetings are held a considerable time after the end of the half-year. When you are dealing with accounts transmitted at the opposite end of the globe, you cannot get the details home in time to give them quickly, and if you postpone your meeting there will be immediately an objection made that we had the accounts two or three months before we gave the information, so that between the Scylla and the Charybdis the directors are in rather a difficult position. Any gentlemen who wish for explanation of the accounts, or to see them in greater detail, can get that information at the office, where I am sure we shall be delighted to afford it. I am director of one company where they publish the accounts in the form indicated by the gentleman opposite, and therefore I have no objection to it, but when you want to adopt it here, I have given you the reasons why it is not advisable to do so.

Mr. GRIFFITHS: There is one other question as to the length of cable in stock, and whether its insulation is likely to be injured by being kept in stock?

The CHAIRMAN: We have, I believe, about 450 miles.

Mr. WEAVER, general manager: A portion of that length is on board one of our ships for the purpose of repairing. But we have 367 miles of deep sea Atlantic cable, part of which we inherited from the French Atlantic Company at the time of the Amalgamation, and which is there for the purpose of repairing deep sea faults.

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Mr. NEWTON: I think you have misunderstood me, and in justice to myself I will explain the inquiry I made. I have here the accounts of the Direct Company made up for the half-year ending June 30, and out of the expenditure they give twenty-seven different items. Here are the accounts of their line, and here are your own; if there is no difficulty for the Direct to do it, you can do it, and information which is not prejudicial to the Direct cannot be prejudicial to the Anglo-American; and I mean, Sir, to move a resolution "that your accounts be furnished on the same principle as those of the Direct Company." Will any one second that resolution?

A SHAREHOLDER: I have pleasure in seconding it. I did not gather from your speech, my lord, any valid reason why it should not be adopted, and, if you cannot give us any, I shall have pleasure in seconding it.

The CHAIRMAN: I am afraid you are out of order. At present, I cannot put the resolution until I have put the resolution before the meeting.

The resolution for the adoption of the report was then put to the meeting, and carried unanimously.

The CHAIRMAN: With reference to the suggestion that has been made, I will undertake to bring it before the Board, and we will give it our best consideration, and I would rather not have a resolution apparently in opposition.

A SHAREHOLDER: There can be no serious objection.

Another SHAREHOLDER: I think it ought to be put to the meeting.

A third SHAREHOLDER: I have no doubt you will adopt it without any resolution.

The CHAIRMAN: Well, we will give it our best consideration.

Mr. NEWTON: I should like to point out that we shall be enabled to compare the accounts published on the principle of the "Direct" with the accounts now published. We shall then take the different items and compare them with the lump sum.

The CHAIRMAN: I hope you will be satisfied with this. I have already told you I belong to two Boards which publish their accounts in that form, and I will bring the matter before my Board now. This concludes the business of the meeting.

Mr. GRIFFITHS: We can hardly separate without proposing a vote of thanks to our able Chairman.—Mr. NEWTON: I beg to second that.

The resolution was cordially agreed to.

The CHAIRMAN: On the part of the Board, I beg to thank you, gentlemen.

The meeting then separated.

THE DIRECT UNITED STATES CABLE COMPANY, LIMITED.

The second ordinary general meeting of the company was held on Friday last, at the Cannon-street Hotel; Mr. John Pender, M.P., in the chair.

The CHAIRMAN said that before making any general remarks he might as well draw attention to some points in the accounts. It would be seen that the revenue for the half-year, after deducting payments to the associated companies, amounted to 79,852*l*. 11*s*. 5*d*., and the working expenses, cost of repairs, interest on debentures of old company, and all other charges, absorbed 29,725*l*. 14*s*. 10*d*., leaving a balance of profit of 50,126*l*. 16*s*. 7*d*. This amount, added to the sums brought forward from last half-year, produced a total amount of 66,443*l*. 6*s*. 7*d*., which has been dealt with in the following manner:—An interim dividend of 5*s*. per share for the quarter ending 31st March last has been paid, and a further distribution of a similar amount is proposed for the June quarter, requiring, together 30,355*l*., making a total of 5 per cent. for the year. From the balance of 36,038*l*. 6*s*. 7*d*. the sum of 32,155*l*. 3*s*. 7*d*. had been placed to reserve, and 1,000*l*. written off preliminary expenses, leaving a balance of 2,938*l*. 3*s*. 7*d*. to be carried forward to next half-year. The message receipts for the half-year offered no reliable comparison with those of the corresponding period of 1877, in consequence of the shilling tariff being in operation for two months in the latter period and the injurious competition existing during the major portion of the half-year ending June, 1877. The ordinary expenses had been less than the preceding half-year by some 1,600*l*. per annum, thus showing that the reduction of about 24,000*l*. a year in the ordinary expenses of the company, as compared with the old company, had been fully maintained. The first year's working of the reconstructed company might be summed up as follows:—Total receipts, 164,070*l*.; total expenses, including 13,520*l*. for repairs, 54,770*l*.; leaving a profit of 109,300*l*. Out of this amount three interim dividends of 5*s*. per share had been paid, and a further final dividend at the same rate was proposed, making 5 per cent. paid in dividends for the year, or a total of 60,710*l*. The sum of 44,655*l*. had been placed to reserve, less 4,655*l*. paid to the Anglo Company, 1,000*l*. had been written off preliminary expenditure, and an amount of nearly 3,000*l*. was carried forward to the next half-year. He had great pleasure, at this, the first annual meeting of the reconstructed company, in congratulating the shareholders on the great success which had attended the action of the directors. The arrangement entered into with the Anglo-American Company had worked to our entire satisfaction. The company's relations with the American and Canadian Governments had been uninterrupted, nor had the action of the company since the last meeting been in any way questioned, nor could he conceive that they were likely to be, because the action of the company was right, and, as far as the public was concerned, it had been beneficial, and as long as the company pursued the policy of making moderate charges to the public, and reduced charges to the Press and Governments, he believed the company would continue to receive encouragement from the Government at home and abroad, and also from the general public. The short section of the cable had again been interrupted, and when they considered the period at which it took place, and the locality of the breakage, they would find it was an interruption of the same nature as had occurred before, namely, from the cable having been grappled by a fishing smack. The interruption extended close upon five months, and the expenditure upon the repairs was consequently very considerable. Fortunately for the company, it had not caused any appreciable diminution in the revenue beyond what was required for the repair of the cable, and this furnished another evidence of the great benefit derived from the security given to this company in the arrangement with the Anglo-American Company. At the last meeting he referred to the removal of the cable from Brown's Bank to deeper water; this question had had the serious consideration of the board, and had it not been that the expenses of repairing the cable had been great, the removal to deeper water would in all probability have been completed in the present year. There was another reason which made them delay the removal. The Anglo-American Company had another cable broken on the same bank, and they had decided to take the cable nearer the shore, whereas this company had decided to take it into deeper water; the directors therefore thought it desirable for the Anglo-American Company to complete their repairs first, as the ship belonged to them, and when that repair was completed the directors of this company would get some little knowledge and experience as to whether they should put that portion of the cable into deeper or shallower water [hear, hear]. He had referred to their relations with the Dominion Telegraph Company. He stated at the last meeting that the managing director of that company was on his way to England, and as you have been informed in the report, negotiations are now proceeding between this company and the Dominion Telegraph Company, which it is believed will terminate all existing difficulties with that company. and result in a supplemental working agreement beneficial to both companies. The board were anxious to have a commencing reserve fund of at least 100,000*l*., especially having regard to the length of time the cable had been laid, but they felt they could not pay a less dividend than 5 per cent. to the shareholders. When the 100,000*l*. had been set aside, they would then have to consider what sum should be annually set aside. Had this policy been adopted from the commencement of this cable's existence, that sum would have been already reached. On that point he might carry their memory to the last meeting, when there was a very strong expression of opinion in this room that the reserve fund should be increased; and, looking at the fact that the Anglo-American fleet had just returned from the attempt to repair the cables of 1865 and 1866, without success, it certainly was high time that this company should now look to their reserve. The company was earning a very handsome sum, but, at the same time, the uncertainty of the life of a cable was such that the shareholders would commend the prudence of the directors in putting aside such a sum as would place the company in an independent position in the event of the cable breaking. Another good reason why they should have a good reserve, should anything occur to the main cable, was that their credit would be such that they would have no difficulty in finding funds to lay a new cable, if it was desirable to do so. Therefore, he hoped the policy he had indicated would meet with the hearty approval of the body of the shareholders [applause]. There were many of the old company's shareholders who were becoming impatient at the slow progress of the liquidation [hear, hear]. No shareholder can be more sensible of this than am I and the gentlemen around me, but it is no fault of the liquidators; the fault entirely rests with the dissentient shareholders, who have insisted upon the value of their shares being settled by arbitration. The directors also felt that it was a very severe thing upon the shareholders that this arbitration should have taken place at all. However, those who had gone into it were only exercising their legal rights, but he was sure they were doing it at very considerable inconvenience to the body of old shareholders, because there was a considerable amount of money locked up, and until the arbitration was at an end that sum could not be distributed amongst the general body of the shareholders. He thought they might congratulate themselves upon peace being established throughout Europe. With that peace he hoped they would see a very great improvement in trade generally. It had been very long stagnant, and trade had suffered to a degree which in the whole of his commercial experience he had never before known to exist; but during that depression trade had given evidence of great soundness, and, with returning confidence, be believed that before long they would see a very considerable increase in the general trade and prosperity of the country, and when that came there was no class of property which would benefit more than telegraph property [hear, hear]. Such was the rapidity with which transactions were taken up and carried through, that what would take some months to transact in olden times was now done in a few hours. Consequently the number of transactions was enormously increased, which was facilitated by telegraphic communications; in fact, before long nearly all the trade of the world would be conducted by telegraph, where it used to be by steam and sailing ships. Therefore, they possessed an improving property, and he anticipated great prosperity for it. In conclusion, the Chairman moved the adoption of the report and accounts, and the declaration of a final dividend of 5s. per share, free of income-tax, making, with the interim dividends already paid, a total dividend of 5 per cent. for the year ending 30th June last.—Mr. W. FORD seconded the resolution.

Mr. JACKSON expressed his satisfaction with the policy which had been carried out by the Board with regard to the accumulation of a substantial reserve fund, the necessity of which had been forcibly illustrated by the events of the past few days in connexion with the Anglo-American cables of 1865 and 1866. He believed the Company possessed the finest cable in existence. He asked whether the directors could not negotiate an arrangement by which a deep-sea cable could be laid from Ireland to Newfoundland, either as a separate undertaking, or in concurrence with the Anglo-American Company, with a preference stock of 5 per cent. He asked whether there was any valid reason why the litigation should continue. It would be to the benefit of all the shareholders if the litigation could cease. He saw no reason for a diminution of the confidence which he felt in the company.

The CHAIRMAN said he wished he could endorse all that had been said about the superiority of this company's cable. It would be bad taste on his part to run down their own property, but at the same time he must speak from the experience he had had for many years of submarine cables, and judge of the cable as compared with other cables; and having taken the opinion of experts who knew more than he did of the character and value of cables, he had given them two specimens of cable made by the Telegraph Construction Company, and a specimen of this company's cable, and the report upon them was that one cable was as good as the other, and no better. He pointed out that by the arrangement with the Anglo-American Company this company was secured, even in the event of the cable breaking, but he hoped that when the cable was worn out the company would be prepared to go into the market with money in hand, and obtain a new cable on advantageous terms.

The report was then unanimously adopted.

On the motion of Mr. JACKSON, seconded by Mr. WREFORD, the auditors (Mr. John G. Griffiths and Mr. J. Sawyer) were re-elected, and on the motion of Mr. BURT, seconded by Mr. JACKSON, a vote of thanks was unanimously passed to the chairman and directors, and the meeting broke up.

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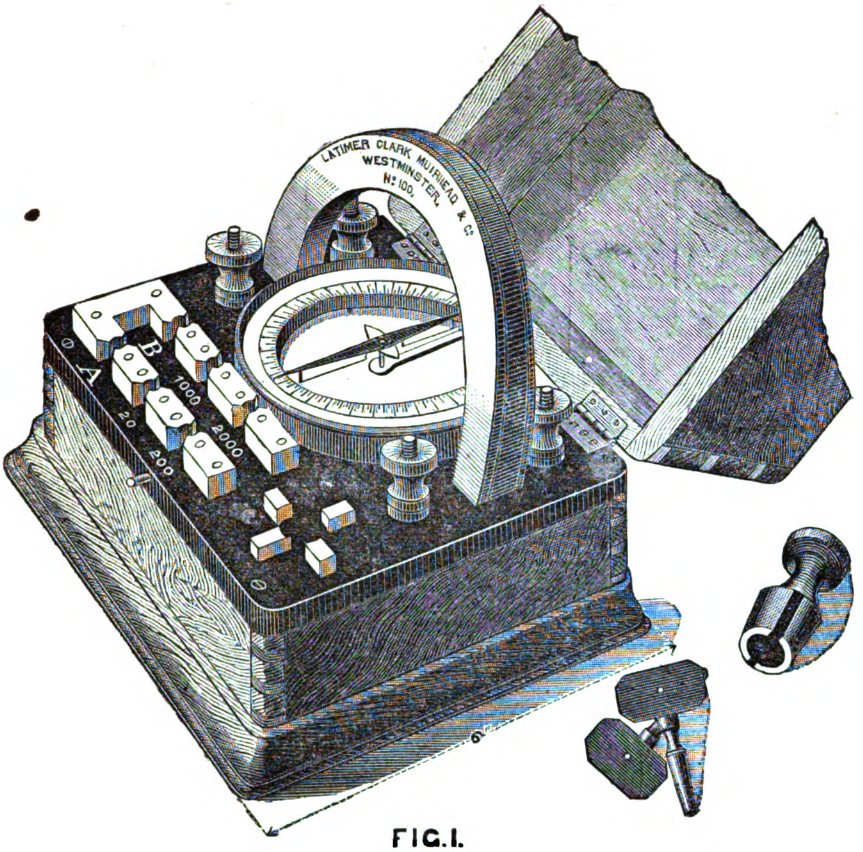


FIG. I.

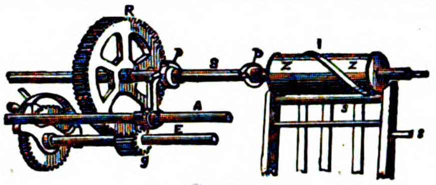


FIG. 3.

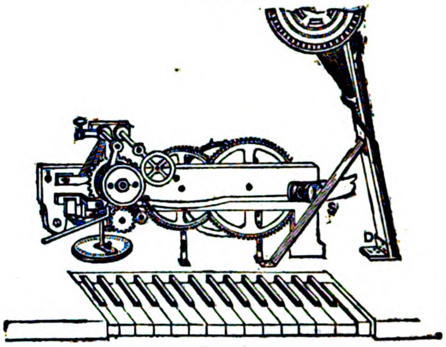


FIG. 4.

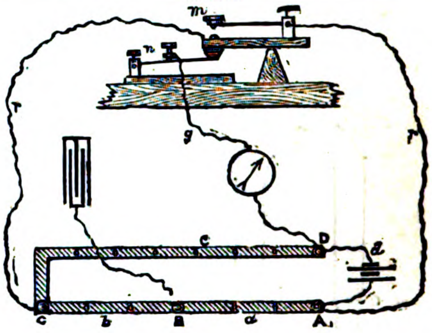


FIG. 9.

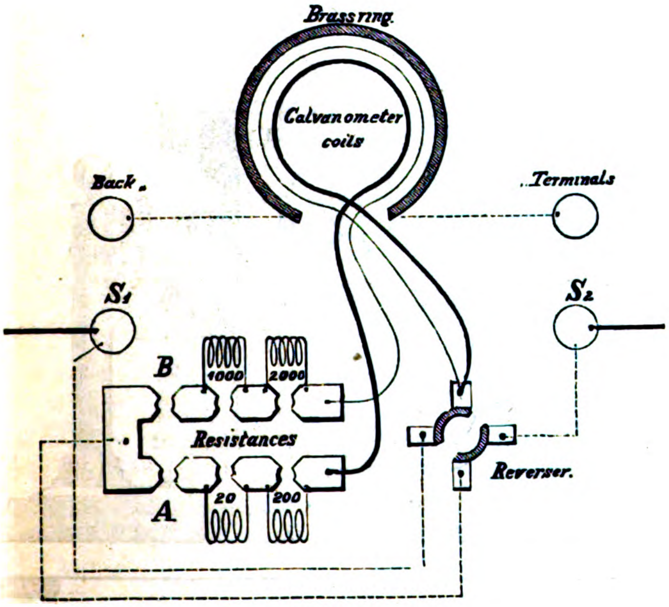


FIG 2.

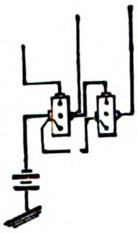
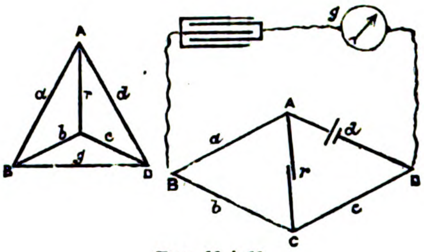


FIG. 6.



FIGS. 10 & 11.

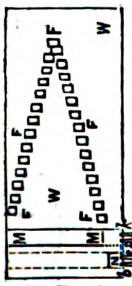


FIG. 8.

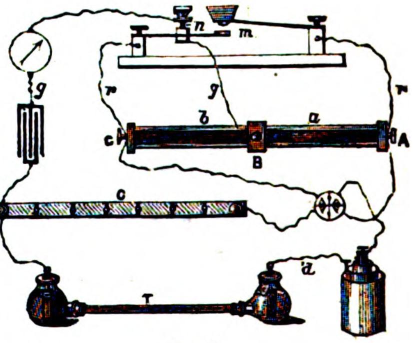


FIG. 12.

FIG. 5.

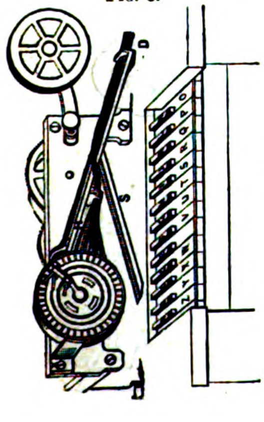
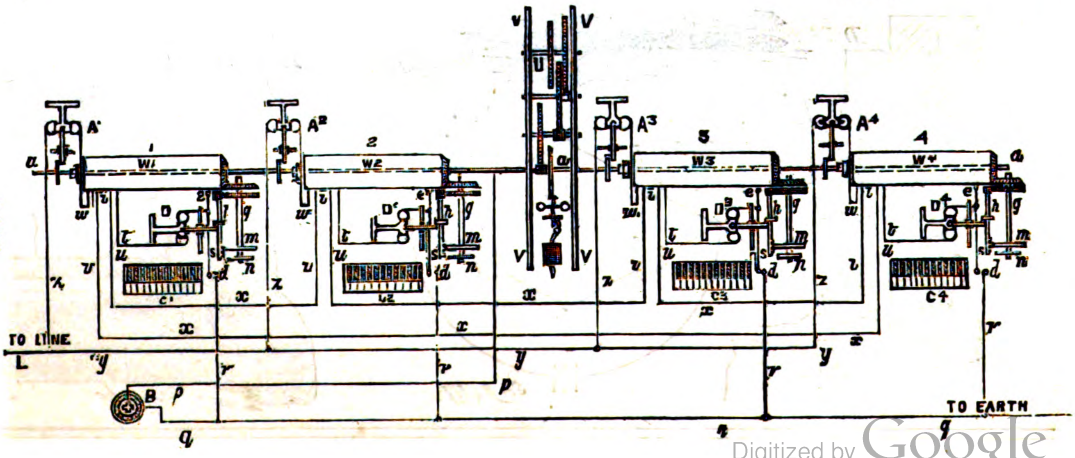


FIG. 7.



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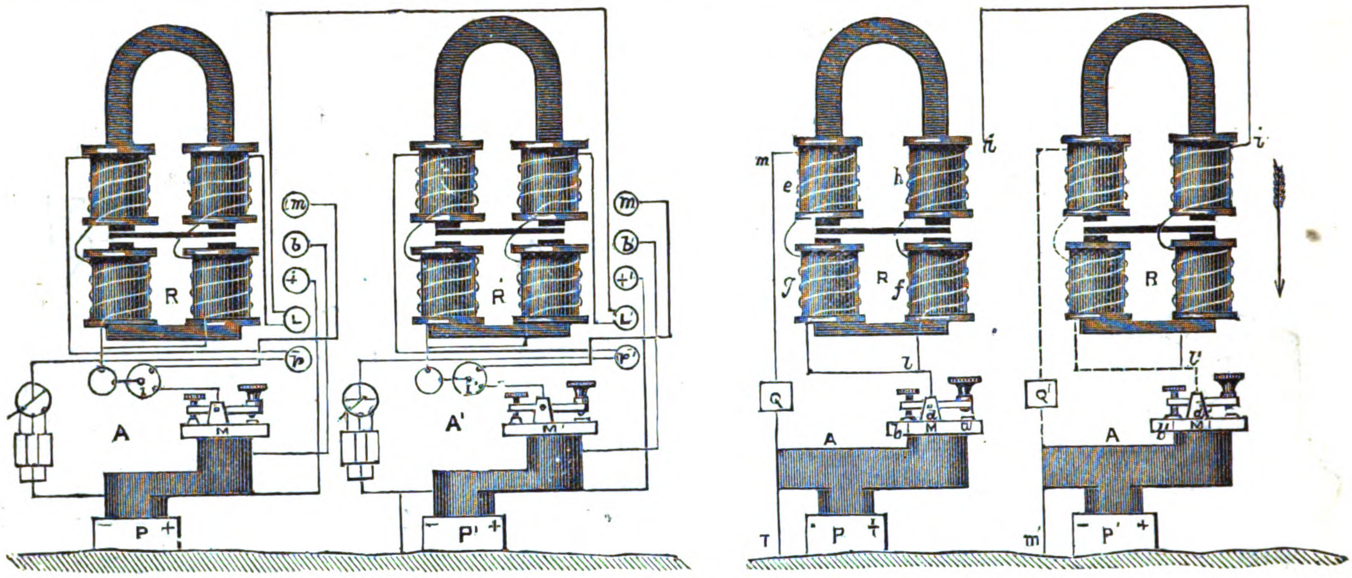
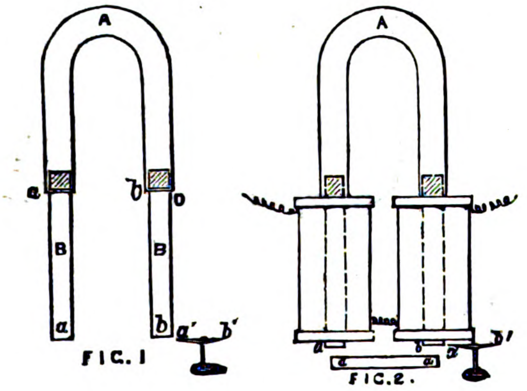


FIG. 4.



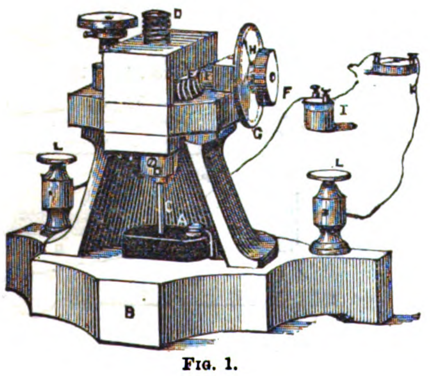


FIG. 1.

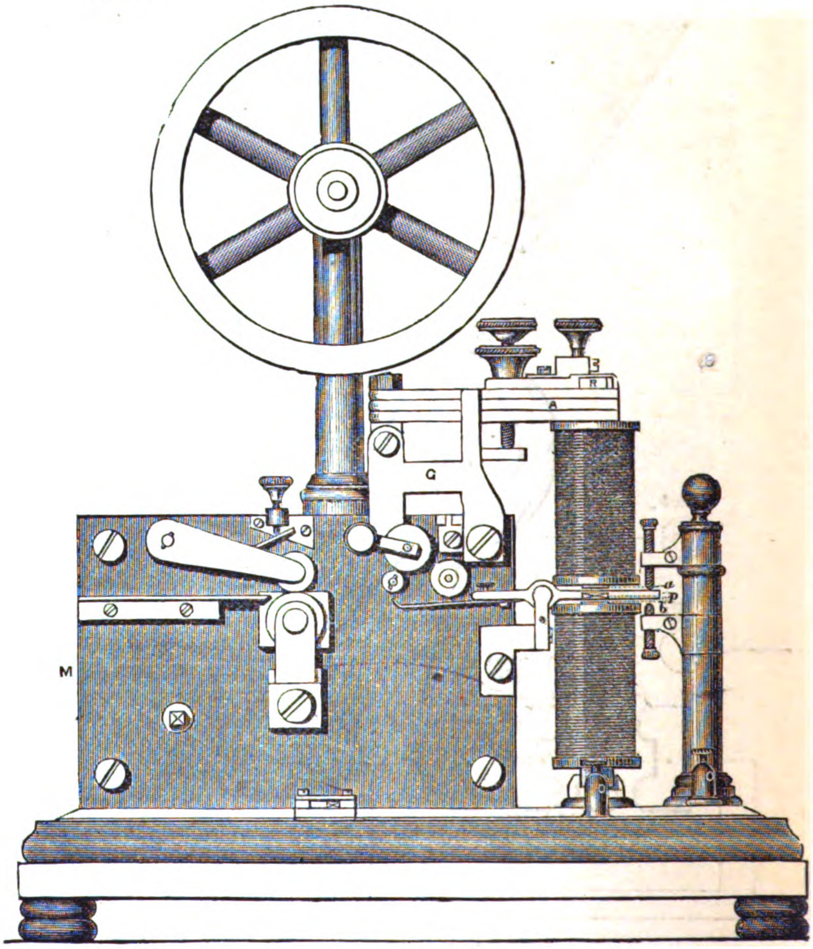
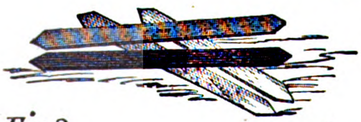
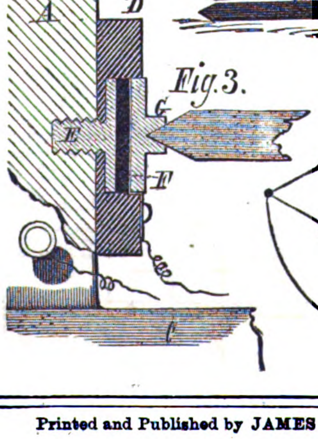
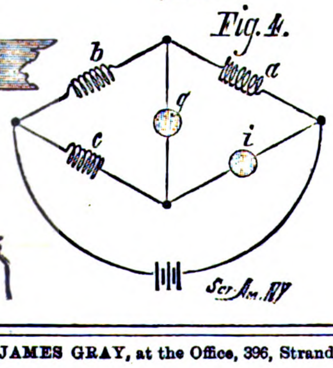
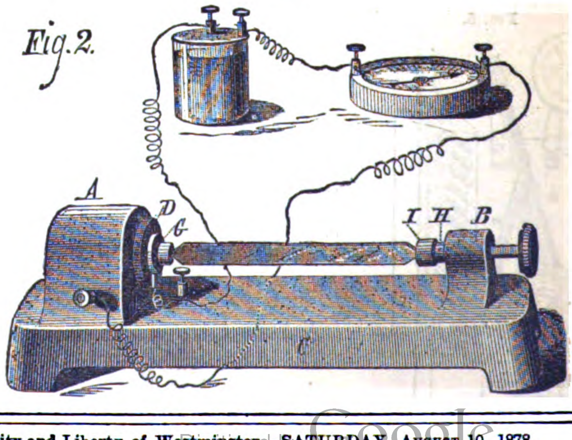


FIG. 3.









Printed and Published by JAMES GRAY, at the Office, 396, Strand, in the City and Liberty of Westminster.—SATURDAY, AUGUST 10, 1878.

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NOTES.

Duplex Working.—The longest circuit working duplex is from Salt Lake to Virginia, a distance of 678 miles.

Quadruplex Working.—The longest line worked on this system is from Pittsburg to St. Louis, 687 miles. This line was first worked in April, 1876.

A New Metal.—Under the name of "Mosandrium," Mr. Lawrence Smith announces the existence of a new metal analogous to cerium and terbium, but having plainly individual characteristics.

Italian Telegraphy.—At the close of 1877 the staff employed in the Italian telegraphic service comprised 4,549 persons. The length of the network in operation was 14,836 miles. The number of offices was 1,292, and the number of apparatus in these offices was 2,137.

Electric Candle.—L. R. Longworth, of Cincinnati, O., claims the following plan of constructing an electric candle. His device consists of two concentric cylinders of carbon, one surrounding the other, the outer and larger cylinder being hollow for that purpose. The space between the two carbons is occupied by a hollow cylinder of some insulating substance, holding the carbons a suitable distance apart.

India-Rubber, Gutta-Percha, and Telegraph Works Company.—In the half-yearly report of the India-Rubber, Gutta-Percha, and Telegraph Works Company (Limited and Reduced), it is stated that the total balance in profit and loss account for the six months ending June 30 last amounted to 44,549*l.* The directors recommend an interim dividend at th rate of 5 per cent. per annum, which will absorb 11,750*l.*, and it is proposed, for the present, to carry forward the remainder.

Indo-European.—An extraordinary general meeting of the Indo-European Telegraph Company (Limited) will be held on Friday, the 23rd inst., for the purpose of considering, and, if so determined, approving or adopting, and authorising the carrying out of a co-operative working agreement between the Indo-European Telegraph Department of her Majesty's Indian Government, the Eastern Telegraph Company (Limited), and the Indo-European Telegraph Company (Limited), relative to the division between the three administrations of the revenue derived from the transmission of Indian and Trans-Indian messages, and of passing such resolution or resolutions in regard thereto as may be approved.

Electro-Metallurgy of Cobalt.—(A. Gaiffe in *Compt. Rend*).—The author has been struck with the beauty of cobalt galvanically deposited as well as by its hardness. It is not oxidised like iron, and much less care is required to keep its surface in good condition. Its beautiful white colour will make it suitable for the decoration of other metals. The bath used was a neutral solution of the double sulphate of ammonia and cobalt, which does not require nearly so much care as the nickel baths. The anode may be a sheet of platinum, or, better, a plate of cobalt, either cast or forged. To obtain a white and adhesive deposit the current ought to be regulated at the outset at six units of electromotive force of the standard of the British Association, and be brought to three units only when the entire surface of the article to be coated has become white.

Remarks Concerning the Influence of Atmospheric Electricity of Low Tension upon Vegetation.—Referring to M. Grandeau's paper "On the Influence of Atmospheric Electricity upon the Nutrition of Plants" (*Comptes Rendus*, lxxxvii., No. 2), M. Berthelot recalls the analogy of the result with his own experiments on the formation of nitrogenous matters under the influence of atmospheric electricity. Hitherto, in agricultural chemistry, there has been understood, under the name of atmospheric electricity, merely the formation of nitric and nitrous acids and their ammoniacal salts produced by the passage of lightning, without any idea of the direct reactions which may come into play between plants and the atmosphere. Yet these latter seem to me the more important, the smallness of the effects being compensated by their duration and by the extent of the surfaces influenced.

The Telephone in America.—A capital exhibition of the powers of the telephone was given recently at Brooklyn in the schoolroom attached to Dr. Wells's church. The Edison carbon telephone was employed as the transmitter, and a new and powerful instrument, known as the Phelps crown telephone, as the receiver. A large paper cone was employed to reinforce the sound at the receiving end. The circuit was not of any large extent, being only from the pastor's dwelling-house, near the room where the lecture was given, but similar effects could doubtless have been obtained over many miles of wire. Solos and four-part songs, speeches and guitar-playing, were heard with distinctness, and, thanks to the cone, with surprising loudness by every one in the room, which contained an audience of about three hundred. The quality of the tones was clearly recognised, not merely the pitch, and the voice of Dr. Wells could be instantly detected from the others.—*Echo.*

Dimensions of Lightning Rods.—Dr. Nippoldt, in a note from the Paris Observatory, objects to the dimensions proposed by Kuhn. Designating by W the heat developed in the rod, I the intensity of the current, r the specific resistance of the conductor, l its length, g its section, s its density, w the specific heat, M the mass, t the temperature, he deduces, by electro-dynamic laws, the equations:—

$$t = \frac{W}{t\,g\,s\,w} = \frac{I^2\,r}{g^2\,3\,w}.$$

The temperature is, therefore, independent of the length of the conductor. The metals commonly used are the following:—

	w.	*s.*	*r.*
Iron	·1138	7·75	·0986
Copper	·0951	8·95	·0162
Lead	·0314	11·35	·0199
Platinum	·0324	21·54	·0918

If we adopt 144 square millimetres as the proper section for an iron rod, copper would require 90 sq. mm.; lead, 320; platinum, 156. In these estimates the copper is supposed to be absolutely pure. According to Matthiessen, the pressure of $\frac{1}{2}$ per cent. of iron trebles the resistance.

An Electric Manometer.—*La Chronique Industrielle* describes a new manometer of a sensitiveness which is said to be almost absolute. This instrument is the result of a combination of two apparatus already known—Bell's telephone and the batoreometer of Professor Giordano of Naples. The latter instrument is designed for measuring thicknesses, or the minutest variations of thickness. Thus, after having measured the thickness of a pane of glass at an ordinary temperature, the batoreometer will show the increase of thickness which results from expansion due to the warmth of the hand which holds the pane. A vertical tripod is traversed by a very fine micrometer screw, and surmounted by a dial, the border of which is marked off into divisions according to

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a certain scale. The object is laid upon the table, and the micrometer screw caused to approach it. As soon as contact takes place an electric current, shown by a galvanometer, passes between the point of the screw and the table. If the object to be measured is a poor conductor, it is coated with gold leaf. Let us now suppose that a current of air, whose intensity we wish to measure, is exercising a pressure on the flexible membrane of a Bell's telephone; the membrane will bend under the influence of an extremely small quantity, but this quantity can never be so minute as to be inappreciable by the electric current of a batoreometer. The new instrument is extremely sensitive to movements of the air, and detects and records even the waves produced by ordinary noises. It is both a manometer and anemometer of great accuracy.

New Method of Electro-Plating.—A new method of electro-plating has been discovered by Professor A. W. Wright, of Yale College, New Haven, Ct., which promises to be of great utility. Taking advantage of the fact that the various metals may be volatilised by the electrical current, he provides a hollow vessel, from which the air is partially exhausted; within this vessel he arranges opposite to each other the two poles of an induction coil; the article to be electro-plated, a bit of glass, for example, is suspended between the poles; to the negative pole is attached a small piece of the metal that is to be deposited on the glass. From three to six pint Grove cells are employed, yielding, by means of the induction coil, an electrical spark from 2in. to 3in. in length. Under the influence of this spark a portion of the metal of the electrode is converted into gas, or volatilised, and condenses upon the cooler surface of the suspended glass, forming a most brilliant and uniform deposit. The thickness of the plating thus produced may be regulated at will, by simply continuing the action of the electricity for a longer or shorter period. That the metal is actually volatilised is proven by the examination with the spectroscope during the progress of the operation, the characteristic lines of whatever metal is used for the electrode being fully revealed. This may be classed as the discovery of a new art, and is certainly very interesting and remarkable. In brief, it consists in plating the surface substances with metals; by exposing such surfaces to the hot vapours of whatever metal it is desired to plate with. Professor Wright has already made a number of valuable practical applications of his discovery.—*American Journal of the Telegraph.*

Experiment for Illustrating the Terrestrial Electrical Currents.—The following experiment enables a lecturer to exhibit to a large audience in a very simple way the action of the currents of electricity that pass around the earth. A rectangular frame, made of light poplar wood, of section three by two centimetres, with sides in length a fraction over a metre, and in breadth three-fourths of a metre. About the perimeter of this rectangular frame twenty coils of insulated copper wire, each extremity of the wire terminating near the centre of one of the shorter sides, and passing through the wooden frame, is fastened and cut off about three centimetres from the frame. This rectangular frame is then so suspended in a horizontal position, by wires attached to the frame of an ordinary hydrostatic balance, that the longer sides are at right angles with the beam. By adjusting weights in the pans the index of the balance can be brought to the zero point. Two small orifices bored in a block of wood a centimetre apart serve as mercury cups, in which the extremities of the short terminal wires are immersed. Near the bottom and through the walls of these wooden cups are screwed small brass hooks, which serve as connections, to which the wires of the battery are attached. The balance is now so placed that the longer sides of the suspended rectangle are at *right angles with the magnetic meridian*, or in the *magnetic* east and west line. When the current from the battery is made to pass around the rectangle from east to west on the northern side, and from west to east on the southern side, by the theory of terrestrial magnetism, the northern side of the rectangle would be attracted and the southern side repelled; and that this is so the corresponding deflection of the balance renders plainly visible. When the current is reversed the deflection is in the opposite direction. By breaking and closing the circuit at proper intervals to augment the oscillations the large frame is readily made to oscillate through an arc of five degrees. When the sides of the rectangle are placed north-east and south-west the current produces no sensible effect. A bichromate-of-potash battery of sixteen cells, with plates of zinc and carbon twenty-five by six centimetres, is used. With a rectangle containing a large number of coils of wire attached to a very delicate balance, by using a *constantly-acting* battery the variation in the magnetism of the earth might be advantageously observed.

Balata, a Substitute for Gutta-Percha.—From a contribution of Dr. W. Riegler, in the *Wochenshrift des niederoesterreichischen Gewerbe-Vereines*, we glean the following facts relating to this new article of commerce, which bids fair to become of great importance, in view of the constantly-increasing demand for elastic gums and the rapid destruction of the trees which furnish rubber and gutta-percha:—Balata, which has only been known for a short time, is inferior in the extent of its uses to caoutchouc, but surpasses gutta-percha, and is said to have already become an important article of commerce. It is the milky sap of the bully tree that flourishes on the banks of the Orinoco and the Amazon, in South America. The operation of winning the gum is similar in every respect to that employed with caoutchouc and gutta-percha, and need not therefore be described. It resembles gutta-percha so closely in its general properties that much of it is shipped from Guiana and sold yearly for gutta-percha, although it has many points of superiority. It is tasteless, gives an agreeable odour on being warmed, may be cut like gutta-percha, is tough and leathery, is remarkably flexible, and far more elastic than gutta-percha. It becomes soft, and may be joined piece to piece, like gutta-percha, at about 120° Fahr., but requires 270° Fahr. before melting (higher than gutta percha). It is completely soluble in benzole and carbon disulphide in the cold. Turpentine dissolves it with the application of heat, while it is only partially soluble in anhydrous alcohol and ether. It becomes strongly electrified by friction, and is a better insulator of heat and electricity than gutta-percha, on which account it may find considerable application for electrical and telegraphic uses. Caustic alkalies and concentrated hydrochloric acid do not attack it; but concentrated sulphuric and nitric acid attack it as they do gutta-percha, which it closely resembles in all other properties. We have in balata, says Dr. Riegler, a body characterised not so much by the possession of new properties, but rather a new member of the group of useful elastic gums, taking rank between caoutchouc and gutta-percha, which may, under many circumstances, be found to be more valuable than either; and it is a matter of congratulation that the world has been supplied with another and abundant source of eleastic gum to swell the supply which the rapid destruction of these trees threatened to seriously diminish.

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THE ABSOLUTE UNIT OF ELECTRICAL RESISTANCE.

BY PROFESSOR H. A. ROWLAND.

[CONCLUDED FROM P. 124.]

Results.—The constant corrections are as follow for the first needle:—

$$a = -\tfrac{1}{2}\lambda + \frac{5}{12}\lambda^2 = -\,{\cdot}00711,$$
$$b = -\tfrac{1}{2}t = -\,{\cdot}00020,$$
$$c = -\,{\cdot}000006,$$
$$d = +\,{\cdot}000074 \text{ at } 20^{\circ}\text{C.},$$
$$e = \frac{1}{128_n\lambda}\left(c_1^{\,2} - c_n^{\,2}\right) = +\,{\cdot}00003,$$
$$f + {\cdot}00003,$$
$$a + b + c + d + e + f = -\,{\cdot}00718.$$

For method of recoil it becomes — ·00016.

Hence, for A and B, log K = 11·4536030.
„ A and C, log K = 11·2852033.
„ B and C, log K = 11·1886619.
For method of recoil, using A and B, log K = 11·4566630.

For second needle and method of recoil,

$$a = -\tfrac{1}{2}\left(\frac{\lambda}{\pi}\right)^2 = -\,{\cdot}000050,$$
$$b = -\tfrac{1}{2}t = -\,{\cdot}00025,$$
$$c = -\,{\cdot}000006,$$
$$d = +\,{\cdot}000074,$$
$$e = +\,{\cdot}00003,$$
$$f = +\,{\cdot}00003,$$
$$a + b + c + d + e + f = -\,{\cdot}00017.$$

For A and B, log K = 11·4566587.
„ A and C, log K = 11·2882590.
„ B and C, log K = 11·1917176.

The distance of the mirror from the scale varied between 192·3 and 193·5 cm.

Should we reject the quantity 34·831 in the third experiment, so as to make the mean result of that experiment 34·744 instead of 34·773, we should obtain as a mean result of the whole

34·7156 ± ·0053,

which has a less probable error than when the above observation is retained. The number of plus and minus errors are also more nearly equal, and the greatest difference from the mean 1 part in 1,100. However, the two results do not differ more than one part in 10,000. We shall take

$$R = 34{\cdot}719 \pm {\cdot}007\ \frac{\text{earth quad.}}{\text{sec.}} \text{ at } 17^{\circ}\text{C}$$

as the final result.

Discussion.—On glancing over the table we see that the number of negative errors greatly exceed the number of positive, but, if we take only the four errors which are greater than 1 part in 5,000, we shall find two of them negative and two positive.

Combining the results with the different coils, we have:—

A and B .... 34·696 ± ·005
A and C.................................... 34·744 ± ·011
B and C.................................... 34·716 ± ·007

Had we no other result to go by, we might suppose that the value of M might not have been found as exactly for these coils as we have supposed them to be. But, if we include the preliminary results, rejected on account of the imperfect circle used, we shall find:—

A and B .... 34·704 ± ·006
A and C .... 34·718 ± ·017
B and C .... 34·758 ± ·016

which has the greatest error in an entirely different place. From the first series the probable error of each determination of M is 1 in about 2,000. But, as this includes the experimental errors, which are about equal to $\pm\frac{1}{4000}$, the real probable error of M must be about 1 part in 2,500. The number of observations is, however, too small for an exact estimate of the probable errors. Taking the results with currents of different strengths, we find:—

For strongest current .... 34·716
„ medium „ .... 34·715
„ weakest „ .... 34·727

which are almost perfectly accordant. Taking the result from the method of recoil and the ordinary method, we find:—

For ordinary method.................... 34·726 ± ·010
„ method of recoil.................... 34·705 ± ·006

If the probable error is subtracted from the first and added to the second, they will very nearly equal each other. Hence the difference is probably accidental. Indeed, by the combination of the results it does not seem possible to find any constant source of error, and therefore the errors should be eliminated by the combination of the result.

In the final result

R = 34·7192 ± ·0070,

the probable error, ± ·0070, includes all errors except the ratio of G to G″. We may estimate the probable error of G at $\pm\frac{1}{3000}$ and of G″ at $\pm\frac{1}{5000}$. Hence the final probable error of R, including all variables, is $\pm\frac{1}{2300}$, or ± ·04 per cent.,

or R = 34·719 ± ·015.

TABLE OF RESULTS.

Induction coils.	Method	T	Tem. of Standard.	β	δ	α	θ	Corrections. A + ·000	Corrections. B − ·00	Corrections. C + ·00	Corrections. D − ·000	Resistance in earth quad. / sec.	Mean resistance in earth quad. / sec.	Error.	Percentage error.
A & C	0	7·800	18°·7	220·17	170·19	40° 12′·44	42° 32′·56	19	075	036	22	34·672	34·748	+ ·029	+ ·083
	0	"	"	185·61	141·28	35 29·06	37 22.94	"	"	029	"	34·784			
	0	"	"	173·83	131·40	33 43·56	35 28·01	"	"	025	"	34·787			
B & C	0	7·800	20·3	222·20	137·07	40 27·81	42 49·81	21	145	036	74	34·760	34·714	— ·005	— ·014
	0	"	"	186·66	113·70	35 41·94	37 33·69	"	"	029	"	34·680			
	0	"	"	174·64	105·71	33 55·87	35 35·94	"	"	025	"	34·702			
A & C	0	7·806	21·0	219·66	168·16	40 7·56	42 18·06	22	176	035	44	34·762	34·773	+ ·054	+ ·155
	0	"	"	184·92	139·65	35 26·37	37 7·87	"	"	025	"	34·725			
	0	"	"	173·20	129·84	33 40·75	35 13·06	"	"	024	"	34·831			
A & B	0	7·822	24·7	208·65	235·98	38 41·87	40 56·13	29	334	034	44	34·700	34·716	— ·003	— ·008
	R	"	"	176·31	119·20	34 10·50	40 57·17	"	"	102	"	34·733			
		"	"	165·20	117·48	32 30·56		"	"	126	"				
B & C	0	7·826	25·4	211·15	129·29	39 3·87	41 19·19	32	370	034	44	34·730	34·718	— ·001	— ·003
	0	"	"	178·01	107·48	34 27·31	36 13·25	"	"	027	"	34·723			
	0	"	"	166·96	100·27	32 46·12	34 19·87	"	"	025	"	34·700			
A & B	0	7·828	25·9	210·53	237·74	39 1·69	41 11·62	32	392	034	43	34·665	34·685	— ·034	— ·098
	0	"	"	177·71	197·72	34 24·00	36 7·50	"	"	025	"	34·704			
	0	"	"	166·32	184·35	32 40·00	34 14·56	"	"	024	"	34·686			
A & B	R	11·488	19·8	219·62	85·407	40 0·16	42 14·65	21	123	039	33	34·701	34·688	— ·031	— ·089
	R	"	"	185·15	84·651	35 20·82		"	"	108	"	34·667			
	R	"	"	173·64		33 37·31		"	"	129	"	34·697			
A & C	R	11·497	20·6	216·80	56·630	39 37·43	41 35·22	22	158	030	22	34·724	34·712	— ·007	— ·020
	R	"	"	183·38	56·059	35 2·81		"	"	100	"	34·725			
	R	"	"	172·92		33 31·25		"	"	121	"	34·688			

Mean, 34·7192. ± 0070

The probable error of the British Association determination was ± ·03 per cent., not including the probable error of the constants; and of Kohlrausch's determination ± ·33 per cent., including constant errors.

Comparison with the Ohm.—The difficulty in obtaining proper standards for comparison has been explained above, and I shall have to wait until the arrival of the new standard before making the exact comparison. At present, I give the following results, which seem to warrant the rejection of Messrs. Elliott Brothers' 10-ohm standard, and to make that of Messrs. Warden, Muirhead, and Clark correct. I shall designate the coils by the letter of the firm, and by the number of ohms. Experiment gave the following results:—

W (10) = 1·00171 × E (10), experiment of June 8, 1877.
W (10) = 1·00166 × E (10), „ Feb. 23, 1878.
W (1,000) : W (100) :: W (10) : ·99376 E (1) experiment of February 23, 1878.

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Now, the greatest source of error in making coils is in passing from the unit to the higher numbers. As the reproduction of single units is a very simple process, the single ohm is, without much doubt, correct, and as the above proportion is correct within one part in 8,000 of what it should be, it seems to point to the great exactness of the standards then used, seeing that the exactness of the proportion could hardly have been accidental. It is also to be noted that Messrs. Warden, Muirhead, and Clark's 10-ohm standard agreed more exactly with a set of coils by Messrs. Elliott Brothers than their own unit E (10). The resistance of any coil as derived from the different standards is as follows:—

From Elliott Bros. resistance coils		34·979 ohms.
,, ,,	10-ohm. standard	35·083 ,,
,, W., M., and C.'s	,, ,,	35·024 ,,
,, ,,	100-ohm. ,,	35·035 ,,

These give for my determination the values of the ohm as follows:—

From Elliott Bros. resistance coils.........		·99257 $\frac{\text{earth-quad.}}{\text{sec.}}$
,, ,,	10-ohm. standard	·98963 ,,
,, W., M., and C.'s	,, ,,	·99129 ,,
,, ,,	100-ohm. ,,	·99098 ,,

For the reasons given above I accept the mean of the two last results as the value of the ohm. To preserve my standard I have made two extra copies of it, the one in German silver and the other in platinum silver alloy. The comparisons are given below. No. 1 is in German silver, and the other in platinum silver alloy. The temperature is 17° C.

No. I.	1·00034	June, 1877
No. I.	1·00029	Feb., 1878
No. II.	·99630	June, 1877
No. II.	·99932	Feb., 1878

These are the values of the copies in terms of the original standard, whose resistance is 34·717 $\frac{\text{earth quad.}}{\text{sec.}}$ From these results it would seem that the German silver of which the standard No. 1. were composed was perfectly constant in resistance. The wire has been in my possession for several years, and seems to have reached its constant state. The final result of the experiment is 1 ohm = ·911 $\frac{\text{earth quad.}}{\text{sec.}}$

—*American Journal of Science and Arts.*

GENERAL CONSIDERATIONS UPON TELEGRAPHIC TARIFFS.*

[CONTINUED FROM P. 100.]

In either of the cases precedingly mentioned, the survivor remains master of the ground, although with losses to repair, probably with higher charges—circumstances which can only tend to the increase of rates, or defer all the longer the gradual reductions which the public might hope for.

The two companies cited have been able to agree, because their object is not the same, and because they encounter each other only upon a small part of their respective systems. But such an agreement divides the traffic between them at double cost, which the ordinary conditions of telegraphic service do not admit of being done with success.

The report mentions also that in 1871 the charge of five dollars (25·80f.) is the maximum for great distances, all the higher rates, some of which amounted to 10 dollars, being thereby repealed, while the maximum has been again reduced in February 1873 to 2 dollars 50 cents. (12.90f.). But that is nearly the maximum of all Europe, even where it is divided between four or five offices, and where it corresponds, as we have seen, to a system three times as important.

We may then conclude that the facts known in regard to the working of overland telegraph systems show us monopoly producing cheapness and competition causing relatively higher tariffs.

3. *Does the solution of the two preceding questions apply to submarine lines?*

The conditions are essentially different.

The inland system of a country principally serves the public of the country (internal correspondence or exchanged with abroad), and accessorily messages in transit. A submarine line only serves for transit (†).

The conditions of transit by a land system are ruled by the principle of reciprocity. The State to which the system belongs can and ought to demand that its people obtain equivalent or proportionate advantages in the other countries.

This question of reciprocity is entirely foreign to submarine lines.

Of equal length, and to serve the same traffic, these lines are much more expensive to establish than land lines, and their maintenance is subject to much more onerous contingencies.

These considerations go to show that in submarine telegraphy, a monopoly, governmental or otherwise, will not always result in cheapness. The sacrifice being for the profit of all the world, no State, no enterprise, would have an interest to make it.

If it was admitted, on the contrary, that a submarine enterprise ought to regulate its tariff to obtain profits, how can we justify the grant of these profits, to which a large number of countries would contribute, to one State, or to a given monopoly, rather than to any other?

It is, then, the force of circumstances which has placed international submarine lines in the hands of private enterprises, who make a profit in return for their expenses and risks.

Is this to say that it is necessary to admit and desire in these enterprises unlimited competition? We do not think so.

Monopoly by right, or, in fact, *without any restriction*, will lead, it is true, to prohibitive tariffs, and check the correspondence. But opposition without restriction will cause either the ruin of essential enterprises or combinations, of which we have given an example, and which are inevitably followed by increase of tariff.

The wisest solution seems to have been pointed out several years ago by Sir James Anderson* in a paper read before the English Statistical Society on the 18th June, 1872.

We will quote some passages of this interesting lecture:—

"Many Governments seem to delight in giving all sorts of concessions. We are never without a threat of opposition in one or more quarters, and there cannot be a more difficult question for the consideration of directors,† than that of determining when it is expedient to make the sacrifice of lowering the tariff or extending their lines.

"There is only one way by which the full benefit of telegraphy can be obtained for the public at the expense of private enterprise. Governments could give monopolies with expressed conditions of a maximum tariff and reserve, and require that all revenue in excess of these amounts should be given to the public either in the shape of increased facilities‡ or reduced charges.

"The present insecure system is open every hour to competition, and can only result in amalgamation and higher tariffs to produce dividends for the greater amount of capital unnecessarily expended. This amalgamation will probably only be effected after one or more companies have been almost ruined. I would, as a matter of private opinion, prefer the conditional monopoly referred to in granting which the Government could stipulate that 2 per cent. upon the capital should be laid aside for renewals, repairs, and extensions, before any dividend was given to the shareholders; that this reserve should be continued and used for such extensions as the increase of trade demanded; and that no dividend in excess of 8 per cent. should be divided until every facility in the shape of reduced tariff and extensions had been supplied to the public that the Government might judge to be desirable.

"This plan, or some modification of it, would ensure the maintenance of an efficient and reliable means of communication; it would ensure to the commercial public a supervision which would give them a reduced tariff whenever it became reasonable to do so; it would ensure to the shareholders a comparatively sound investment; in a very few years the reserve and the duplication of the lines, with the aid of this reserve, would make their dividend absolutely secure, but for this they would be required to sacrifice dividends.

"If this or some similar plan is not devised, then the alternative is that Government should obtain the whole of the telegraphs, and, by making them only self-supporting, give the public the full advantage the system is capable of affording."

We have already mentioned the circumstances which render this last solution less practical when it is applied to international submarine lines, of which the maintenance and good service interest a large number of countries.

Let us have the system proposed by Sir James Anderson. If it is true that this proposition is dictated by the interest of submarine enterprises, one could not deny, on the other hand, the high ability of its author, nor the force of his arguments. To a

* Translated from the *Journal Télégraphique.*

† We except submarine lines connecting two parts of the same State (England and Ireland), or even two neighbouring States (Sweden, with Denmark or Germany), when other countries make very little use of this communication.

* After having directed, as naval officer and commander of the Great Eastern, the submersion of the first Transatlantic cables, Sir James Anderson has continued, as director, to give his attention to these enterprises. He represented at the St. Petersburg Conference the Brazilian Submarine, Eastern, Eastern Extension, and Anglo-American Telegraph Companies.

† The managers of submarine telegraph companies.

‡ Extension of sytems and conducting wires.

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certain extent the general interest is bound up with the interest of enterprises devoted to the public.

The conditional monopoly proposed would impose upon the company less sacrifices than unlimited competition, and would leave them more security.

The public would entirely profit by these sacrifices, whereas by competition it profits only partially and temporarily.

4. *Can a lowering of the tariff have for its result an increase in the receipts? Can this effect extend to the net receipts, all expenses being deducted?*

Whilst putting this question, we think it necessary to assert that the solution of it is still doubtful for many competent authorities. We will content ourselves with quoting one.

At the two last general meetings of the shareholders of the Submarine Telegraph Company, the president of the administrative council of this company, referring to the results of the St. Petersburg Conference, expressed his regret at not seeing amongst them a general reduction in the European tariff. His opinion is thus expressed, according to the report in *The Times*:—

(Meeting of the 24th August, 1875). "The delegates (at St. Petersburg) did not deem it desirable to modify the charges for the general telegraphic business of Europe, and therefore they maintained the tariff *in statu quo*. Personally, the President would have been delighted to see a moderate general reduction carried out, for he thinks that such a reduction, prudently made, always brings about an increase of business, and encourages the public to correspond more frequently than heretofore; but, as he said at first, the delegates of the different Governments thought otherwise."*

(Meeting of the 22nd February, 1876). "At the last meeting, he (the President) referred to the conference which had been sitting at St. Petersburg, and expressed regret that a general reduction of tariffs had not been proposed at it. He has nothing to retract from what he then said; he still thinks that a moderate reduction of tariff would be to the advantage of the company, and he also thinks that so prosperous a company ought to treat the public liberally. The company, however, is not like those of the Atlantic cables, which may at their pleasure make a charge for one word of either a guinea or a shilling. It is bound by its concessional contracts to work in agreement with its own government and those of foreign nations."

The liberal intentions expressed in the name of the administrative council of the Submarine Company do not leave us free to suppose that their regrets refer to anything else but a reciprocal and proportionate reduction, in which this company would have taken part in proportion to its share of present charges. Now, if the report is correct, and if we have translated it accurately, the opinion of this council, which is eminently competent to judge, and directly interested in the question, is clearly that a reduction of tariff would increase the net receipts.

We have, therefore, some excuse for referring to the facts which contradict this opinion.

A complete study of these facts, in so far as the home and foreign telegraphic communications of Belgium are concerned, was published officially in 1870. An abatement in the international tariffs had been asked for by private persons, newspaper proprietors, chambers of commerce, and members of the Legislature. They dwelt upon the apparent anomaly between these tariffs and the charge for home messages, and they predicted, as a result of the measure demanded, an increase in the receipts similar to that which it was said had been brought about by the successive reductions of the home administration.

It is true that these reductions had been followed year after year by an increase in the gross receipts. Thus, the home tariff having been reduced from one franc to half-a-franc on the 1st of December, 1865, the receipts of 1866 (407,532frs.) had exceeded those of the previous year (345,289frs.). But, in considering only these two figures, they did not take into account, 1st, what the receipts would have been in 1866 by the natural development of business without any change of tariff; 2nd, how much less the expenditure would have been on the same hypothesis. On the other hand, they supposed, incorrectly, that the effect of reductions is as favourable in foreign relations.

The law of 1851, which confers upon the Belgian Government the power to fix the tariffs and the regulations for telegraphic communications, was to cease to have force in 1870; and the Department of Public Works being under the necessity of asking for a prolongation of these powers, this opportunity was seized on to set forth the real facts relating to reductions of tariff by reconstructing, according to probabilities, the business as it would have continued as to receipts and expenditure if the old tariffs had been maintained.

Applied to a period of twenty years (1850-1869), this labour gave, as a result of all reductions in tariff, a loss of 2,548,106f., allowance being made for 678,719f. for additional lines and apparatus.

Similar deductions were applied separately to the home service and to the international communications of the last ten years (1860-1869), taking into account the reaction of one branch of business upon the other to modify the return.

These deductions led to the following conclusions:—"The returns of the Belgian telegraphic lines have gone on diminishing during several years past, so as to be reduced nearly to zero in 1868.

Nine-tenths of this result must be attributed to the successive reductions in international tariffs, and the rest to the reductions in the home tariff.

It is true that the home service, looked at separately, showed a deficit before the reforms of 1863 and 1865; and that these reforms slightly increased the deficit. But this increase is only about 160,750f.

The international service has always given a profit. But the successive reductions of our tariffs for foreign countries have reduced this profit by about 938,300f., relatively to what would have been the state of affairs if the tarifis of 1860 had remained in force.

In this imaginary case there would have been, from 1863 to 1869 inclusive, 1,199,850 home telegrams. The reduced tariffs gave 4,364,810, that is 3,164,960 more in seven years, or 452,000 more per year. The public Treasury has paid for this quadrupled business by a sacrifice of 160,750f.

With the same hypothesis there would have been, from 1861 to 1869 inclusive, 1,589,200 telegrams between Belgium and foreign countries. The reduced tariffs brought in 2,304,803, that is 715,603 more in nine years, or 79,510 per year. This increase of 45 per cent. caused a decrease in the profits of 938,300f.

There is thus an enormous difference in the results of reforms of tariff, according as they are applied to the home service or to foreign communications. If we examined separately the effects produced upon even the closest international communications (that is to say, those with immediately adjacent countries), we should find a confirmation of this difference, an explanation of which is easily found.

Classifying telegraphic communications according to their object, we obtain, from the statistics for 1869, the following average distribution for 100 telegrams:—

	Telegraphic correspondence.		
	Home.	Foreign.	Together
Messages sent by Government and the Diplomatic offices	½	¾	½
Exchange news	5	12½	8¾
Commercial transactions	34	56¼	45
Private and family relations	59½	28¼	44
Newspapers	1	2¼	1¾
	100	100	100

Contrary to what is generally supposed to be the case, the Government and diplomatic communications, exchange and Press news, far from forming the main object of telegraphy, amount to only 11 per cent. of the whole business, 6½ per cent. for the home service, and 15½ per cent. for foreign relations abroad. Nine-tenths of telegraph lines are taken up by two principal streams of messages, viz., business communications, which make use of the telegraph more or less readily in proportion as political or other circumstances render commercial transactions active or dull; and family and social communications, which increase year by year, as this means of correspondence becomes popular, and, by successive reductions of tariff, penetrates gradually into the middle and lower regions of private life.

As we might expect, these two streams do not stand in the same relation one to another in the home service and in the foreign service. Private and family connections are much less numerous beyond the frontiers. They form only 28¼ per cent. of the international correspondence, whereas they constitute 59½ per cent. of the home business. On the other hand, business telegrams absorb 56¼ per cent. of the international correspondence, and only 34 per cent. of the home service.

[TO BE CONTINUED.]

* It is evident that the honourable president, in pronouncing these words, had no intention to say that the delegates had failed to recognise this evident and incontestable fact, that a reduction of tariff brings about an increase of correspondence. He, no doubt, meant to say that the delegates, not counting sufficiently (as he thought) upon the development of business to hope from it for an increase in the net receipts, had not ventured to recommend a general reduction of the international tariff. Contrary to the assertion quoted, the St. Petersburg Conference thought general modification of this tariff very desirable. After seeking for some means of obtaining it without seriously compromising the revenue, the majority fixed upon a system due to the initiative of the Russian Administration, which consists in granting a reduction of 40 per cent. to telegraphic messages of ten words, exempted from all accessory operations which might cause expense to the administrations. If this reduction has not become general, it is because several offices (amongst others, that of Great Britain), and as a necessary consequence, the Submarine Company, formally refused to accept it.

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THE ELECTRICIAN.

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Nous serons heureux de faire l'échange avec Messieurs les Rédacteurs des Journaux scientifiques qui recevront les premiers numéros de L'ELECTRICIAN.

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I Signori Editori di giornali scientifici che riceveranno i primi numeri dell' ELECTRICIAN *ci faranno cosa gradita accettando il cambio che loro offriamo.*

THE BRITISH ASSOCIATION AT DUBLIN.

As we are going to press, we learn that the Annual Meeting of the British Association for the Advancement of Science has been opened at Dublin, and we hope next week to have to record a pleasant and profitable meeting. There have been rumours, indeed, of local dissatisfaction that Irishmen have been passed over in choosing the president and the officials of sections, and for this reason, it is said, subscriptions are not coming in as freely as might be expected from the proverbial openhandedness of our Hibernian hosts; but this is, perhaps, only the inevitable grievance without which the Emerald islanders cannot have their minds at ease. In their past experience of the British Association they certainly cannot complain on that score. The last meeting held in Ireland, at Belfast, was presided over by an Irishman of cosmopolitan fame, who, moreover, contrived, figuratively speaking, to set the shillelaghs going pretty briskly. When, twenty-one years ago, the Association last met in Dublin, the president was the present Provost of Trinity College. Now that the meeting is to be held within the walls of this ancient institution, the sons of Erin will not grudge the honours due to a Saxon like Mr. William Spottiswoode.

It must be confessed that Ireland cannot claim pre-eminent distinction in the studies fostered by the British Association. The fervid minds of her people have always been (with some most notable exceptions whose fame is universal) more at home in literature and oratory than in pursuits more connected with the sternest and baldest prose. Trinity College herself has few names to show of men distinguished in science; her enemies even say that the most celebrated sons of the "silent sister" have been chiefly distinguished in their relations to her by idleness and unruliness. Her *raison d'être* in the past has been controversial theology, an atmosphere fatal to the growth of Huxleys and Tyndalls. Times are changed, and she is changing with them. She has now in some respects taken the lead of her scornful sisters, Oxford and Cambridge, not to speak of Durham, that Cinderella of Universities, and, emancipated from old chains, has a fresh career before her in which she will be free to rival London in all which such new schools have done and are doing to foster true scientific thought. But as yet her Tyndalls and Thomsons have generally sought their distinction elsewhere.

If Ireland be not yet at the head of the world in science, no one ever doubted her character for hospitality. Several excursions and entertainments are already arranged, which will bear out this character to the members of the Association, some of whom, it is shrewdly suspected, are less concerned about scientific progress than securing for themselves a pleasant holiday with sight seeing and good company galore. By the way, the circular announcing these jaunts and jollities, shows a fault which is surely not Irish. In a printed paper issued by a dignified Reception Committee, on behalf of a learned society, and signed by two LL.D.'s, one Lord Mayor, and other grave and reverend seigniors, we are somewhat surprised to read of "a number of excursions, *both* on the Saturday during the meeting *as well as* on the Thursday which follows it." Our editorial pen itches to be at such slipshod sentences as "We have reason to *believe* that a considerable degree of private hospitality will be extended to the distinguished guests *which* may honour Dublin with their presence. As supplemental to private hospitality there will, we *believe*, be no deficiency in hotel and lodging accommodation." A useful list of the said accommodation is enclosed with the circular, in which we find the word *set* half a dozen times misprinted for *let*, and a house described as having a garden front and *rere*. We do not wish to be hypercritical, so we will not frown at the Dublin printers' spelling; but is it the phonograph and the microphone that the secretaries of the Reception Committee expect as the most distinguished guests *which* are to honour Dublin with their presence? Science is indeed mighty, but she cannot yet afford to break Priscian's head, or set her conquering foot upon Lindley Murray.

We must, however, turn aside from noticing such trifles, to consider the more weighty matters which have given this Association its pre-eminent position amongst similar scientific bodies. The Transactions of the British Association contain a mine of scientific wealth which the student should never neglect. There is hardly a branch in the whole range of science but is made clearer by close attention to the papers read at these meetings. Experimentalists, so to speak, keep the records of the best of their work during the year to surprise their co-workers who visit the sections; thinkers show how the experimental data point to new and hitherto undiscovered laws; and all go back to their arduous work with a feeling that link after link is being added to the chain, and one by one nature's secrets are being wrested from her grasp to weld the nations and bring about the reign of universal brotherhood.

We cannot as yet say what discoveries will be discussed at this meeting, or whether in electrical science anything as startling as the telephone or the microphone will astonish the assembly; but we do know that papers of interest, dealing with gaps that discovery has left, will be read, and these may, if rightly used, prove of the greatest importance. In looking back to the last meeting at Dublin, and the readers of papers at that meeting, we find many a void. The worker has gone to his rest, and left others to take up the thread of discovery.

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But, on the other hand, many who were then entering the paths of science are still to be found in the old haunts performing great and good work. In 1857 the following gentlemen contributed electrical papers:—Prof. W. A. Miller, "A Report on Electro-Chemistry;" Capt. Blakely, "On Cables;" Prof. Callan, "On the Electro-Dynamic Induction Machine;" Mr. J. Hartnup, "On Controlling the Movements of Clocks Electrically;" Gen. Sabine, "On Magnetic Disturbances;" Professor Rogers, "On an Induction Apparatus;" M. Louis Soret, "On the Correlation of Dynamic Electricity and other Physical Forces;" Prof. W. Thomson, "On Whitehouse's Relay," and again, "On Induction in Cables;" Mr. J. Drummond, "On a Theory of the Magnetic Phenomena of the Globe;" and Mr. W. Rundell, "On Magnetic Experiments on Board the *Great Eastern*." Prof. Loomis read an extremely interesting paper, "On Certain Electrical Phenomena," similar to those described by a correspondent in our issue of June 1. Mr. A. H. Hamilton and M. l'Abbé Moigno, Sir J. Richardson, Prof. G. Wilson, Mr. J. S. Beattie, Mr. C. Brooke, Sir J. Murray, and Mr. A. Balestrini, each added to the theory or the practice; so that, on the whole, the last meeting at Dublin was very satisfactory as regards electrical matters.

It may be said that none of these subjects presented any special novelty, but, at the same time, the number of papers shows that the subject was prominent in the minds of scientific men; and, if that was the case then, what can we say of it now, when, after more than twenty years, the discoveries have become more rapid and more wonderful? *Then*, a submarine cable was a subject of unsolved difficulties, empiricism had to make way for science, the thread to join America to Europe had not been laid, duplex had dropped stillborn from the hands of Gintl, Hughes was on trial. *Now*, more than sixty thousand miles of cable testify to our progress, America speaks not by one but by half-a-dozen wires, duplex is a success—is being pushed hard by quadruplex and sextuplex, Hughes is a household name—as are dozens of other names belonging to workers in the domain of electricity.

THE IMPROVED HUGHES TELEGRAPH APPARATUS OF A. E. GRANFELD, VIENNA.*

(CONTINUED FROM PAGE 137.)

With a slow motion of the writing apparatus, the beginning of the line is shifted towards the edge of the strip lying nearest to it, and with a quicker action towards the other side, and, at the same time, the writing becomes more crowded in the first case, more open in the second. When the velocity of the working gear becomes so great that the writing cylinder completes its revolution in a shorter time than the index requires to traverse a fifth part of the contact plate, then, and not till then, can a portion of the sign become absorbed or remain unwritten. Hence the velocity of the working gear might relatively increase upwards without entailing any detriment.

Now, Granfeld has essayed to employ in the working gear Hughes instruments that have become worn out or need repair, whereas it is obvious that new ones, especially if made expressly for this purpose, would be more advantageous. But to the Hughes printing axle it was possible to attach the writing cylinder without further trouble, as the Hughes ratchet-wheel works well only when the type-wheel makes from 70 to 140 revolutions per minute, at which rate the printing axle would require 6·49 to 3·49 of a second for one revolution, giving too quick a motion for the writing cylinder. Hence Granfeld attaches the writing cylinder Z Z (Fig. 3†) with the writing tape I, which makes 4·5 to 2·3 of a complete turn, to a special axle S, together with a wheel R of 90 teeth, which fits into a pinion or cog-wheel *g*, with 18 teeth, attached to the printing axle E. To the new axle S is further applied an eccentric wheel *e*, which, after a complete revolution of the writing cylinder thrusts aside an arm *h* attached to the axle of the ratchet lever (disconnecting lever), which is thus turned, but thereby brings back the anchor lever (retaining or grappling lever) to the pole of the electro-magnet, at the same time again releasing the coupling of the printing axle E with the axle of the fly-wheel. Lastly, there is further applied to each new axle S a second eccentric wheel *p*, which advances the tape the width of one line with each revolution of the writing cylinder Z.

Each main apparatus receives as a further improvement an index attached to a short axle, its own axle being simply screwed on to that of the printing wheel, when the instrument is intended to be used as a multiplex telegraph. Then the contact plate of the distributor, which is fastened to a wooden bar (with prop S), revolving with it round an axle at D, is also removed from the position in Fig. 4 to that in Fig. 5, and attached to the side of the appparatus with two screws *x x*. The index carries two contact springs in the form of two-pronged forks; the inner fork moves on the two inner contact rings, the outward over the two exterior ones. The former transmits to a local battery the current necessary to release the working apparatus; the latter in the transmission directs the current to the line, in the reception conducts the line current to the electro-magnet of the *n* working apparatus, which by the attraction of its anchor moves towards the writing cylinder the paper-rod *s*, together with the tape passing over it. In the outermost ring of the contact plate are groups of three contacts, of which the first is employed to produce a dot, the first and second together a dash, while the third is connected with the earth for the purpose of discharging the line, that is, through the "line relay" (linienrelais), receiving the arrival currents, so that this may also detect the interruptions of such currents that may possibly occur on the said contacts. Between the first and last *n* parts lie three contact pieces, which with each stoppage enabled corrections to be given and taken, besides acting as self-corrector.

For the transmission there were at first employed five pairs of keys, as Granfeld attached great importance to the possibility of an unabbreviated repetition of the signs for the ten ciphers, each of which in the Morse alphabet consists of five elements. But experience showing that misreadings (mutilations) were not to be feared, this power became less important, and the fifth pair was consequently omitted. The insertion of one pair is shown in Fig. 6. By pressing the dot key (to the right) the battery transmits the current from its axle to the first contact piece belonging to this pair; by pressing the dash-key (to the left) it transmits it from the axles of both keys simultaneously to the first and second contact pieces. When both keys are at rest the wire running from the resting contact (ruhecontact) of the dash-key conducts to earth, through the line relay, the currents arriving by the first and second contact pieces. The transmitted signs are also written off, but by means not of the line relay, but of the equally polarised "pole relay." Granfeld employs *two* relays in order the easier to obtain a good command over the transmitted and arriving currents, which differ materially in their strength. At first, to each working apparatus he gave its special line and pole relays; but for all *n* working apparatus he now employs one line and one pole relay only. The moments when the message from the keys touched by the telegraphist is to be expected and when it is completed are clearly indicated by the coupling and uncoupling of the proper working apparatus.

At the trial on the Vienna-Prague line in the week ending January 12th, taking the daily average, there were forwarded by each working apparatus from 12·8 to 22·6, or an average of 15 telegrams, each of twenty words, per hour. During the week ending January 26 the number rose to from 19·5 to 30, or a mean of 23·8; and during the last three days of the third week ending February 9th, fresh hands were employed, the corresponding numbers for that week amounting to 19·0, 27·9, and 24·8. In case his improvement should be adopted, Granfeld intends to begin with a sextuplex apparatus at least, and thinks he will be able to guarantee on this instrument a performance of $6 \times 30 = 180$ telegrams of 30 words each per hour.

[TO BE CONTINUED.]

* Translated from Dr. Zetzsche's Articles in 'Ding. Poly.'

† *Vide* Supplement to last issue.

SCHWENDLER'S TANGENT GALVANOMETER,

A SIMPLE AND PRACTICAL INSTRUMENT FOR QUANTITATIVE ELECTRICAL MEASUREMENTS.

(Compiled by O. HENNEBERG, M.S.T.E., from Schwendler's 'Testing Instructions.')

[CONTINUED FROM PAGE 140.]

Theory of the Instrument.

The coils of the instrument being set in the magnetic meridian, a current passing is proportional to the tangent of the angle to which the needle is deflected.

The best deflections are those of about 45°. Above 45° the tangents increase very rapidly with the angles, and consequently unavoidable observation errors will throw out the result very much; and besides, the tangent law is more rigorously true for

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small than for great angles. Under 45° the observation error, which may be taken as a constant, becomes a sensible portion of the whole deflection, and has, therefore, a large percentage—influence.

A current C is proportional to the tangent of the angle of a degrees, to which the needle is deflected, which may be expressed by $C \propto \tan. a$. For another current $C_{\prime}$, giving a deflection $a_{\prime}$, we have $C_{\prime} \propto \tan. a_{\prime}$. Comparing the two currents we get, therefore:

$$\frac{C}{C_{\prime}} = \frac{\tan. a}{\tan. a_{\prime}}.$$

If we designate by H the horizontal component of the earth's magnetic force at the place of observation, then we have $C = \frac{H}{K} \tan. a$, where K is a coefficient of the instrument, which remains constant so long as the coils of the galvanometer are not changed (K depends simply on the make of the instrument and its dimensions.) Hence, if K is determined once for all (for each coil and for the brass ring) and H is known, the little instrument can also be used for executing absolute measurements. However, in our special case the instrument is used only for comparing currents, and therefore it is unnecessary to know the values of H and K.

Supposing now the current C to be produced by an E.M.F. = E of a battery with an internal resistance f. Further, that the resistance of the galvanometer coil be g, and the resistance in circuit external to battery and galvanometer be w, we have $C = \frac{E}{f + g + w}$. Another current, $C'_{\prime}$, produced by another battery of E.M.F. = $E_{\prime}'$ and internal resistance $f_{\prime}$ in an external resistance $w_{\prime}$, would give $C_{\prime} = \frac{E_{\prime}}{f_{\prime} + g + w_{\prime}}$. Hence we have $\frac{C}{C_{\prime}} = \frac{f' + g + w'}{f + g + w} \frac{E}{E_{\prime}}$, and by combining this with the first expression for $\frac{C}{C_{\prime}}$ we have:

$$\text{I.} \quad \frac{\tan. a}{\tan. a_{\prime}} = \frac{f' + g + w_{\prime}}{f + g + w} \frac{E}{E_{\prime}},$$

which is the general formula from which all special applications can be made.

The Use of the Tangent Galvanometer for Measuring Resistances, Comparing Electromotive Forces, &c.

I. *Measuring Resistances.*

a. The Internal Resistance of a Battery.

Connect up the two poles of the battery to be tested of E.M.F. = E and resistance f_1 to the two terminals S_1, S_2, and observe at least two deflections, a and a_1, which the battery will give with two different resistances, w and w_1, with the *one* galvanometer coil in circuit.

Putting $\frac{E = E' = E_{\prime}}{f = f = f_{\prime}}$ in Form I., we have $\frac{\tan. a}{\tan. a_{\prime}} = \frac{f + g + w_{\prime}}{f + g + w}$

$$\text{II.} \quad \therefore f = \frac{w_{\prime} - w \frac{\tan. a}{\tan. a_{\prime}}}{\frac{\tan. a}{\tan. a_{\prime}} - 1} - g.$$

The first deflection we may generally take with no external resistance in circuit, $w = 0$. In this case we have:

$$\text{III.} \quad \begin{cases} f = \dfrac{w_{\prime}}{\dfrac{\tan. a}{\tan. a_{\prime}} - 1} - g & \text{or, more conveniently,} \\ f = \dfrac{w_{\prime} \tan. a_{\prime}}{\tan. a - \tan. a_{\prime}} - g \end{cases}$$

Example.—10 Minotto elements connected up in series give, with the thick coil (g = 1 ohm):—

For $w = 0$ a deflection $a = +70 -71$ mean 70.5,
And for $w_{\prime} = 200$ „ $a_{\prime} = +32 -32$ „ 32.0.
tan. 70.5 = 2.824 tan. 32.0 = 0.625.

$$\therefore f = \frac{0.625 \times 200}{2.824 - 0.625} - 1 = 55.8 \text{ units.}$$

b. Measuring Resistances of Wires, &c.

Resistance to be measured does not contain an electromotive force.

An unknown resistance x, (for instance that of an instrument, of a length of wire, or whatever) may be determined in a similar manner. Connect up one end of the unknown resistance to one pole of an appropriate testing battery, the other end of the unknown resistance and the other pole of the battery being connected up to the terminals S_1 and S_2. Observe the deflection (a) through one—say the thick—coil, with the unknown resistance and the testing battery in circuit *only*, none of the comparison resistances being unplugged, thus:—

$$\tan. a = \frac{E}{f + g + x}.$$

Then remove the unknown resistance, and observe a similar deflection a, with the same battery, through the same galvanometer coil, with a resistance = $w_{\prime}$—say 20 ohms—unplugged when $\tan. a_{\prime} = \frac{E}{f + g + w}$. Combining both equations and developing x, we have

$$\text{IV.} \quad x = \frac{\tan. a_{\prime}}{\tan. a}(f + g + w) - (f + g).$$

The resistance, f, of the testing battery should be ascertained beforehand and introduced into the formula. A fair judgment about the accuracy of the results obtained may be formed by measuring f before and after the determination of x. In order to make the influence, which a certain error in f will always have upon the result, least, f should be selected as small as possible. However, it being a well-known fact that by local action galvanic batteries of low resistances change more rapidly than those of higher resistance, it is not advisable to use cells with an individual *too* low resistance, but to combine a number of cells with greater resistances parallel, and form what is called "a compound cell" for the purpose.

The best proceeding for ascertaining the magnitude of the testing battery is to make, first, a rough measurement of x. This value is then to be used for calculating E and f, in order to get readable deflections (a about = 45°). Then the right testing battery is formed by connecting single cells in series and parallel, in order to get approximately E and f, and with this testing battery the final determination of x is made.

As a rule, f and E should be small when x is small. Further resistances under 600 ohms should be measured by the thick coil, and above 600 ohms by the thin coil.

Example.—Required the resistance of a certain sounder which is known to have a resistance of about thirty ohms. The standard cell, having a resistance of ten ohms, gives a deflection of 6° with the thick coil, and 200 ohms in circuit. Now we require a deflection of about 45°; which number of cells for E should be employed? We have

$$\frac{\tan. 6°}{\tan. 45°} = \frac{0{\cdot}105}{1{\cdot}} = \frac{1 + 30 + 10E}{211\,E}, \text{ or } 22. \quad {\cdot}15\,E - 10\,E = 31;$$

whence E = about 3. Selecting now a battery of three single cells connected up successively, and measuring its resistance, we find it to be f = 28·5 ohms. Then taking readings with the thick coil,

through x alone we have $a = +47{\cdot}5 - 47$ mean 47·25,
through w = 20 ohms $a_{\prime} = 54{\cdot}5 - 54$ mean 54·25.

Determining the value of f again, we find it to be 28. We may, therefore, take 28·25 as the proper value of f during the measurement. Then, by formula IV.

$$x = \frac{1{\cdot}389}{1{\cdot}082} + (28{\cdot}25 + 1 + 20) - (28{\cdot}25 + 1), \text{ or } x = 33{\cdot}97.$$

If more accurate results be desired, the changes of resistances by temperature should be taken into account. The resistance of copper wire (of the galvanometer coils) varies 0·00215 of itself per each degree Fahrenheit (= 0·00387 per degree Celsius), while platinum silver wire (of which the comparison resistances are made) changes just at one-tenth of this rate.

For instance, the temperature at which the experiments were made was 118·5°F., while the resistances are marked to be right at 68·5°F. The thick coil is stated in the memo. to have, at this temperature, the exact value of 1·005 ohms,

$$g = 1{\cdot}005 + (1{\cdot}005 \times 50 \times 0{\cdot}00215) = 1{\cdot}113, \text{ and}$$
$$w = 20 + (20 \times 50 \times 0{\cdot}000215) = 20{\cdot}215.$$

For g and w their corrected values in formula IV. substituted, we get x = 34·29. Corrections for temperature are, however, justified only when we know that our observations are sufficiently correct.

Considering that in observing an angle of about 70° an unavoidable reading error will represent already a fault of about 3 per cent. in the result, we will fix the maximum limit to which readings should be taken at 70°.

In order not to exceed this reading while measuring small resistances, we should calculate the resistance of the testing battery accordingly.

Say, for instance, the resistance to be measured be not larger than 0·5 ohm, then E.M.F. = 1 will suffice, and we have $\frac{\tan. 6°}{\tan. 70°} = \frac{0{\cdot}105}{2{\cdot}747} = \frac{1{\cdot}5 + y}{211}$, or y the resistance of the testing cell = 6·5 ohms.

[TO BE CONTINUED.]

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CORRESPONDENCE.

THE DISPUTED INVENTION OF THE MICROPHONE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The circumstances under which I wrote my letter of the 25th June were plainly stated, and the inferences I then drew have been fully borne out by facts which have since come to light. I do not see that any good can come of the discussion being continued by Mr. Batchelor and myself. When the matter can be very easily set at rest by a little candour and plain-speaking on the part of Mr. Edison, it is difficult to understand why his reputation is left to the imperfect advocacy of his friends. However, that is Mr. Edison's affair; and, as both Professor Hughes's and Mr. Preece's own accounts of the matter are now before the world, friends on either side ought to be silent until Mr. Edison speaks.

As between myself and Mr. Batchelor, I have a word or two to say. I protest against his distorting my letter into an admission that Edison confided anything to Preece. I admitted nothing of the kind; and, certainly, nobody here will admit it now, for, if the fact had been so, we should long ago have had Mr. Edison's categorical statement of the particulars. Secondly, Mr. Batchelor forgets that he is addressing a journal the readers of which may be supposed to understand the real question at issue. They will not be deceived by the quotations with which he favours us, and, indeed, matters are made all the worse for Mr. Edison by their publication. Nobody will believe that he left the diaphragm there merely to do the duty he now assigns to it. The quotations only prove, in fact, that Mr. Edison thinks that a thick diaphragm is "inflexible," and that it does *not* "vibrate!" I protest, also, against Mr. Batchelor's manipulation of quotations. He professes to take from the *Journal of the Telegraph* of the 16th April the following passages:—"I [Edison] discovered that my principle, unlike all other acoustical devices, did not require the vibration of the diaphragm; that, in fact, sound waves could be transformed into electrical pulsations without the movement of any intervening mechanism." As an inventor must be judged by his productions, and not by his speculations, this passage would have proved nothing, even if published as alleged. But, as a fact, the passage *is not there at all!* It may be in Mr, Prescott's book, and we can quite understand its being there. Comte du Moncel has already told us how much he thinks the book is worth as evidence in this matter.

Your readers will be glad to have Mr. Batchelor's assurance that Mr. Edison was graciously pleased to give Professor Bell "full credit" for getting "ahead of him" with the telephone; but they will be curious to know what Mr. Batchelor would have them understand by the following mysterious passage in this portion of his letter:—"At that time he (Edison) suggested to the writer (Batchelor) that in our experiments we keep entirely free from the magneto-principle in our transmission." Is this another specimen of the art of implying a great deal more than may be said outright? Does it mean that Professor Bell discovered the magneto-telephone transmitter *through the forbearance of Mr. Edison?* We should very much like to hear all about it, if it does; if not, what on earth does it mean?

Yours truly, J. LAISTER.

London, 7th August, 1878.

ELECTROMOTIVE FORCE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The question is put (p. 130):—"Is not the increase of electromotive force of one battery over another obtained chiefly, if not entirely, by a more rapid consumption of zinc?" The quantity of zinc consumed has nothing whatever to do with the electromotive force of the system; but it has all to do with the "quantity" or current which that electromotive force can produce. It is the case, as the querist puts it, that where there is a two-fold E.M.F. there is a doubled consumption of zinc (in a circuit of the same resistance), but this is a consequence, not a cause; in consequence of the presence of double force, double current passes; as a necessary accompaniment of this, double consumption of zinc occurs in each cell.

The same weight of zinc gives different electromotive forces, according to the chemical conditions under which it is consumed, and one of the most complete disproofs of the contact theory (that is the theory of the contact of dissimilar metals) is to be found in the fact that the same two metals give very different forces under different conditions. The electromotive force is simply the form taken by the "potential energy" of the several substances set free in the act of chemical combination, and which would, under other conditions, appear directly as heat. I have made a great number of experiments on this subject, and (in reply to the request for reference to published descriptions of such experiments) they are described along with the similar labours of others in the Chapter on Electromotive Force, pp. 207—240 of my book, "Electricity; Its Theory, Sources, and Applications." J. F. SPRAGUE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: If we wish to double the E.M.F. of a battery, we must, by Ohm's law, either halve the resistance, leaving unaltered the E.M.F., or double the E.M.F. without varying the resistance. We will take this latter case, and, in order to carry it out, must first double the number of cells in series and then double the size of the cells, or, what comes to the same thing, double the number of cells in multiple arc. We have now doubled the E.M.F., and thereby doubled the consumption of zinc in the unit of time; but we have also doubled the number of cells in multiple arc, and by doing so redoubled or *squared* that consumption. The consumption of zinc, therefore, varies in the ratio of the square of the electromotive force. L. A. DAVIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR:—In answer to "C. E. B.'s" query, I think he will find all his difficulty solved if he uses the following equation for the amount of zinc consumed in a battery. It is accurate for a Daniell's battery and approximate for others; it is $Z = \frac{E^2 \times 16}{R}$ grains per hour, E being the electromotive force of the battery in volts, R being the resistance of the circuit. Now, if he takes a known value for R, and varies E, he will find that the quantity of zinc is proportionate to the square of the electromotive force; for, taking E of Daniell's roughly at 1, and that of Grove's at 2, and applying the formula, he will find that the zinc consumed varies as the square of the electromotive force.

I cannot refer "C. E. B." to any publication on this head, but I hope that this formula will remove his difficulty.—I am, &c.,

ALFRED C. M. WEAVER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to "C. E. B.'s" query, p. 130, it would, I believe, be more correct to state that the higher electromotive force of the Grove is due to the fact that there is a greater *difference of affinity* for the oxygen of the liquids in the cell between its platinum and zinc than between the copper and zinc of the Daniel.

The increased consumption of zinc in the Grove (provided the circuit of each cell is similar as to resistance, &c.) then follows from its higher E.M.F. J. BROWN.

Belfast.

THEORY OF WHEATSTONE'S BRIDGE.

TO THE EDITOR OF THE ELECTRICIAN.

DEAR SIR: I must ask you kindly to correct, as soon as possible, a slight mistake in my answer (*v.* page 105) that has been printed. It now reads:

$$\therefore \frac{AB}{DE} = \begin{cases} \frac{BE}{EC} + 1 \\ \frac{be}{ec} + 1 \end{cases}$$ and, subtracting equals from equals, the remainders are equal.

$$\therefore \frac{AB}{DE} = \begin{cases} \frac{BE}{EC} \\ \frac{be}{ec} \end{cases} \quad \therefore \frac{BE}{EC} = \frac{be}{de} \quad \therefore BE : DE :: be : de.$$

It should be:

$$\frac{AB}{DE} = \begin{cases} \frac{BE}{EC} + 1 \\ \frac{be}{ec} + 1 \end{cases}$$ and things which are equal to the same thing are equal to one another.

$\therefore \frac{BE}{EC} + 1 = \frac{be}{ec} + 1$, and, subtracting equals from equals, the remainders are equal. $\therefore \frac{BE}{EC} = \frac{be}{ec}$. $\therefore BE : EC :: be : ec.$

Q.E.D.

Hoping I shall not be troubling you too much in asking you to correct this mistake,—I am, &c., ALFRED C. M. WEAVER.

The Brazilian Submarine Telegraph Company's receipts for July were 11,759*l*., against 9,329*l*., showing an increase of 2,430*l*.

The receipts of the Eastern Extension, Australasia, and China Telegraph Company for July amounted to 24,927*l*., against 22,224*l*. in the corresponding month of last year, showing an increase of 2,703*l*.

The traffic receipts of the Great Northern Telegraph Company for July were 18,811*l*. For the seven months ended with July 31 the aggregate receipts were 118,163*l*., against 115,385*l*. and 115,876*l*. in the corresponding periods of 1877 and 1876.

The receipts of the Direct Spanish Telegraph Company for July were 812*l*., while the corrected receipts for the corresponding period of last year were 824*l*.

The estimated receipts of the West India and Panama Telegraph Company for the half-month ended with the 31st ult. were 2,175*l*., against 2,433*l*. in the corresponding period of 1877

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SIGNALLING INSTRUMENTS AND SYSTEMS EMPLOYED IN FRANCE.

The *Journal Officiel* of the French Republic has recently published the following information relative to the signalling systems employed by the French Administration, and to the facilities respectively afforded by them for meeting the increase in the number of despatches consequent upon the reform in the tariff which came into force on the 1st of May last :—

"The fundamental apparatus is the Morse, which is that most widely employed, abroad as well as in France. The number of despatches transmitted by means of this apparatus, with a very skilled manipulator at each end of the line, is from twenty to twenty-five per hour, each of twenty words. The cost price (for receiver, transmitter, and wheel) varies, according to the details of the construction, from 190 to 230f. The expenses of installation are from 80 to 100f.

"Upon lines where the traffic is more active, the Morse is replaced by the printing apparatus of the Hughes system. This instrument, worked by two clerks at each end, allows of the transmission in one hour of fifty despatches having a mean of twenty words. It thus performs double the work of the Morse; but with a double *personnel*. The price of the Hughes apparatus is about 1,350f. It is somewhat expensive to keep it in working order, and this can be done with certainty only by the assistance of special mechanicians.

"On the great lines from Paris to Lyons, Bordeaux, and Marseilles, where even the Hughes apparatus was insufficient, the administration has for the last four years adopted the automatic system of Wheatstone, and the multiple transmission instruments of Meyer and Baudot. The transmission with the Wheatstone system reaches ninety despatches per hour on the Marseilles line, and may exceed this figure on lines of less length. But this apparatus necessitates a numerous staff—at least five, and ordinarily six, very skilled *employés* at each end. A complete Wheatstone apparatus costs nearly 4,000f., say 8,000f. per line. It is expensive to keep in order, and, moreover, the administration has to pay to the inventor's heirs an annual royalty of 2,500f. for each line on which it is worked.

"The quadruple and sextuple apparatus devised by M. Meyer, an officer of the French Administration, can serve for a normal transmission of from eighty to one hundred and twenty despatches per hour, with four to six *employés* at each end. They cost from 4,000f. to 6,000f.

"A quintiple printing apparatus due to another *employé* of the Administration, M. Baudot, has recently undergone a trial between Paris and Bordeaux; the work it performs corresponds to a transmission of two hundred despatches per hour, with at least five *employés* at each extremity of the line. There is every ground for hoping that the employment of this system may be extended when it has received the improvements suggested by the first trials. It is not yet possible to determine the cost price of these apparatus, of which only two working models have yet been constructed.

"The number of instruments in service amounts to three thousand five hundred for the Morse system, and to three hundred and fifty for the Hughes system, which is employed only for comparatively important stations.

"The Administration as yet employs the apparatus of the Wheatstone system upon only four lines, those of M. Meyer upon only two, and those of M. Baudot upon a single line. These lines are amongst those upon which the traffic is considerable; the use of perfected apparatus for rapid transmission will gradually become extended according to the development of the service, which will be a consequence of the reduction of the tariff.

"The duty performed by the Morse, Hughes, and Wheatstone instruments may be, if not doubled, at least augmented to a certain extent, with a double staff, by means of the duplex arrangements, which allow of the simultaneous transmission of two despatches in opposite directions.

"The Administration purposes to utilise the duplex systems, and the perfected apparatus of Meyer, Wheatstone, and Baudot, in order to meet the augmentation of traffic which must be expected upon its main lines. These are the reserve forces at its disposal. But on the principal lines of Paris, Lyons, and Marseilles, every means has been utilised, and at the present moment, in these directions, the reserve is exhausted. In consequence of the extension of the traffic, it is necessary to construct fresh lines connecting Lyons, Marseilles, and Bordeaux, with Paris; these being the points where telegraphic activity is most concentrated."

LITERATURE.

A Search for Fortune. Daldy, Isbister, and Co.

We can commend this book to our readers for its unpretentiousness an, its humorous, vivid, and sparkling style. The autobiographer has doubtless been a great traveller, and he relates his incidents with jovial freshness. The book abounds in thrilling adventures and hairbreadth escapes. The travels described have a range over four quarters of the globe, where the writer appears to have passed a very pleasant if rough time; but he seems to have taken to everything which came in his way in a good-humoured and easy-going style. His lively descriptions of all sorts of sport will be read with interest; nor has he allowed the zoology or botany of the various countries he has visited in South America to pass unnoticed. The author, in relating his American experience, has introduced us to the gentle "Sancho" in his true character, and we recommend all intending emigrants to the "Pampas" to study his work. His final labours seem to have been in the Brazils, whither he journeyed upon the formation of the Western Brazilian Telegraph Company as one of their *employés*, having previously attended an institution where, for certain considerations, the mysteries of the Syphon Recorder were explained and taught, in addition to which a professor lectured upon chemistry, heat, and electricity, and, to quote his own words, "in a wonderfully short time he succeeded in mastering all the various instruments which comprise the *sine quâ non* of a telegraphist's education." Mr. Bucknall favours his readers with a complete history of the W. B. T. Co., and his connection with the same, interspersed with several amusing anecdotes, and concludes with a valuable description of Brazil in general, which will be found most instructive and entertaining, not alone to the naturalist, botanist, entomologist, ornithologist, or geologist, but to the romantically-minded for the book tells a tale of constancy, devotedness, and perseverance, which renders it intensely absorbing and far more interesting than most novels.

THE EASTERN TELEGRAPH COMPANY (LIMITED).

Report of the proceedings at an extraordinary General Meeting, held at the City Terminus Hotel, Cannon-street, on Friday, 9th August, 1878, at one o'clock p.m., John Pender, Esq., M.P., in the chair. The Secretary read the notice convening the meeting.

The CHAIRMAN: Gentlemen, you have in your hands the report giving you the reasons for calling this meeting. In that report we state that we shall move a resolution, and the resolution is—"That this meeting sanctions "and approves the acquisition by the Company of the shares and undertak- "ing of the Black Sea Telegraph Company, Limited, and that the Board of "Directors be and are hereby authorised to do all things needful or expedient "for acquiring the same, and that this meeting also approves of the raising "of monies by the issue of debentures for payment for such shares and under- "taking, and also for the laying of a cable to connect the Island of Cyprus "with the company's existing lines, and generally complete the company's "system of telegraphs in the Mediterranean." Now, gentlemen, I shall make a few remarks upon the desirability of carrying out these recommendations, as your Board considers it is very desirable that we should acquire the Black Sea Cable. When that cable was laid we had no station at Constantinople. During the last twelve months we have had to make some important additions to our system in the Mediterranean, and we have, as one of these important additions, brought Constantinople, I may say, into direct communication through our submarine system in the Mediterranean with England. We have, therefore, secured the privilege of opening an office at Constantinople, the value of this being, I believe, that, while we shall be in a position to manage your affairs to advantage, we have conferred a very great national benefit. It is also of very great advantage to our shareholders, and we feel it is necessary to place that connection in as secure a position as possible. The Black Sea Cable Company is a small company that was opened by a very few individuals for connecting Constantinople with Odessa. The cable has been laid for two years; it has proved to be a very efficient cable, made by the Telegraph Construction Company, and at the present moment it is doing a very large amount of work. I may mention that since the termination of the war the cable has earned something like 10,890*l*. The capital of the company is something like 130,000*l*., and we propose to buy the whole of the shares of the company for 74,000*l*. The advantage to the company I think it is not difficult to see; for if anything like the present traffic is maintained, the returns will be very considerable indeed. No doubt there are gentlemen here who will say, "Why are you buying this property at such a low price?" My answer to that is this: As the Telegraph Construction Company are largely interested in this Black Sea Telegraph Company—in fact, you may say it was both made and laid by them, and as they are cable manufacturers, and not cable workers, we are in a position to deal with them on terms that would have been perfectly impossible had it been in the hands of a neutral and clearly distinct company. As I have said, if anything like the return is maintained that has been obtained during the last six months, I can see a very important addition to our revenue; and, not only that, but it secures to us virtually the whole telegraph system in the Mediterranean. There is in connection with this company some very valuable concessions, which give us for a very long period of years the virtual control of that traffic—for thirty years. Therefore, there are two reasons in favour of securing the company; the one is that it will give us a very handsome return indeed on the amount expended, and the second is that it will do away with the competition entirely in those quarters. Now, gentlemen, I think I have said all I can say in favour of acquiring this Black Sea system. The cable, I believe, is in thoroughly efficient working order; it is a cable that has been made on the first principles, and I believe we are getting it at a very reasonable price indeed. Now, the other matter that I wish to draw your attention to is the importance of connecting our system with Cyprus. You are all very well aware of the great change that has taken place lately, that we have acquired this island, and I daresay there are few in this room that have not looked into the history of it. At one period there were something like a million inhabitants on it, but through misrule there are at present probably only 150,000. Under British rule, however, there can be

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no doubt that there will be an extraordinary increase in the population there. There is an enormous amount of good to be done; there is a great outlet for capital, and while all this is going on there must be a great amount of telegraphic communication, not only with Egypt, but with Italy and England. Therefore, I thought it desirable to avail ourselves of the opportunity of laying a cable from Cyprus to Alexandria, and thereby connecting it with Malta, Gibraltar, and our general Mediterranean system. We are also about to close, in fact the whole question is settled, it has passed the council and is approved by the Grand Vizier, and all it requires is the ratification by the Sultan), with some very considerable advantages in these seas. When that convention is signed I believe we will virtually have the whole control of these seas for Telegraphic purposes, in fact, if any cable is required we will have the first offer of making it. Just for the sake of information, and to give you the full information, I may give you something like an idea of the amount of money required. The cost of the Black Sea Cable, as mentioned in the report, will not exceed 74,000*l*. The cost of the Cyprus Cable from Larnaca to Alexandria will be about 60,000*l*. The cost of the land lines will be about 16,500*l*.; stations, 5,000*l*.; cost of ships engaged with the works, 16,000*l*.; for Tripoli, in Africa, to Malta, and for Red Sea extensions, about 55,000*l*.; leaving a balance for surplus capital and stores of about 23,000*l*. In short, we propose to issue debentures for something like 250,000*l*. I may mention that, in these days of progress, when I believe that Turkey will require to turn over a new leaf and do something more in that direction than she has done for some years if she is at all to keep pace with the progress that is going on in European nations, we may, in fact we are in negotiation now for connecting Jaffa with the Red Sea system, and in doing that I believe we may see when the time comes, as we now see in the case of the Black Sea cable, that it is a desirable thing to do, and that it will be to the pecuniary advantage of the company to do it. I daresay some of you will say we are never at rest, but always doing something [hear, hear]. I am quite prepared to admit that, and to prove that it is absolutely necessary. I do not believe myself that any telegraphic company can ever stand still. It is the leading feature of progress at the present time, and as long as we can keep pace with that progress which demands telegraphic communication, and we can show you that that progress is remunerative to the shareholders, I believe that the body of these shareholders will support us in our policy [applause]. I may say that to-day, although this meeting is a comparatively sparse one, the amount of proxies we have received in support of that policy are very large indeed, and therefore, as they come from all parts of the country, from leading shareholders, I may say that our policy has been very clearly approved by a very large number of shareholders. Now, gentlemen, with these remarks I beg to move the resolution which I have read; but before I put it to you I may say that the amount at which we propose to issue debentures will be 5 per cent., and that they will be offered *pro rata* to the different shareholders. If any shareholder declines to take his proportion, then those who may have applied for a larger number than they are entitled to from the amount of shares they hold will have the first offer of the unappropriated debentures. Now, gentlemen, with these remarks I beg again to read the resolution, as I see some gentlemen have come into the room since I read it before. It is:—"That this meeting sanctions and approves the "acquisition by the Company of the Shares and undertaking of the Black "Sea Telegraph Company (Limited); and that the Board of Directors be, "and they are hereby, authorised to do all things needful or expedient for "acquiring the same; and that this meeting also approves of the raising of "money by the issue of Debentures for payment for such shares and undertaking, and also for the laying of a cable to connect the Island of Cyprus "with the Company's existing lines, and generally complete the Company's "system of Telegraphs in the Mediterranean" [hear, hear].

Lord WILLIAM MONTAGUE HAY (Deputy Chairman): I beg to second that resolution.

The CHAIRMAN: I shall now be glad to hear any remarks you may have to make.

Mr. MARKS: In acquiring the Black Sea cable you must, of course, have a better knowledge than the shareholders generally have of the matter, and whether it is worth the purchasing, but I think that instead of raising it in five per cent. debentures, the amount might be taken from reserve. We have a reserve of 120,000*l*., or thereabouts, and independent of the reserve fund, we have three months of the takings of the Telegraph, which would amount to about 105,000*l*. We are not in the position of bankers; we do not require this large amount invested for the sake of getting 3½ or 4 per cent, and when you go into matters like this, it would be far better—at least, such is my opinion—than borrowing the money at 5 per cent., and then paying others 3½ per cent. With regard to the Cyprus matter you say it would cost something about 60,000*l*. That is a large amount to spend on a telegraph where there are no inhabitants. It is true there are inhabitants, but what are they? They are in a state of barbarism, and have been going on decreasing. We have now ten thousand troops there, but what are they? Why half of them are natives, and where are the earnings to come from in a poor place like that? It may be eventually developed, but I think we should pause before we spend this money on a place with little inhabitants; and who is to telegraph? The Government and the Government only. It is true the place may be a valuable place, and prove hereafter a gem to this country, but it will be a long time before the telegraph is required. It may be that the Government require one, and if so let them construct it, but do not let us spend 60,000*l*. on an uninhabited place which it is a question if we will always hold. The people are half civilised, they do not want a telegraph, and where are the earnings to come from? In fact, instead of being 60,000*l*. it may cost 80,000*l*. or 90,000*l*, and I think you ought well to pause before this is carried out.

Mr. BAYNES: I have on previous occasions called in question the policy of the Directors in regard to these various extensions, and I think the time has come when the shareholders should put their veto on the matter. I find, on looking back to the previous reports, that the dividend used to be more satisfactory than it now is. I think the Directors have succeeded in tiling up the Debentures and preferences to such an extent that the dividend has been creeping down to 5 per cent. I agree with the previous speaker that it is premature to spend a lot of money in making a Telegraph to an island of this sort before there is a development of capital. The time may come when it may be policy to do it, but I think it is now premature. And now, with regard to the Black Sea Cable, people know little about it. I cannot understand from the paucity of information given further than that you have called us together to lend something like 74,000*l*., and then without telling us you spend 250,000*l*. That is not dealing with the shareholders in the manner they ought to be dealt with, and it is a great question whether the shareholders should not put their veto on this lavish expenditure of money. With regard to Joint-Stock Enterprise in Russia—and I suppose the Black Sea Cable goes to Odessa—I can only say this, that, from past experience, and what I have learnt from other information, I believe the Russian Government by no means encourages Joint Stock enterprise in that country, and if you have any difficulties about your business, the Imperial and municipal governments throw every obstacle in your way. It is not so long ago that Odessa was paved by a Company, and before they could recover their fair debt they had to bring an action. There is also a Water Company there with a large capital, and which has a guaranteed dividend of six per cent. by the municipality there. They have, however, the greatest difficulty to obtain this from the municipality. The magistracy of Odessa are elected by the people, and in order to make themselves popular they play into the hands of the people, and it is with the greatest difficulty any Company can get justice. I simply put this before you to show that the Directors ought to make further inquiry. I think the Directors have taken the Shareholders by surprise. They have put before you a statement of 74,000*l*., and when we come here we find a demand for something like 250,000*l*. to be laid out. I think under the circumstances I am justified in moving "that the consideration of "this question be deferred for twelve months."

A SHAREHOLDER: Is there any Telegraphic communication with Cyprus now?

Mr. ROBERTS: You say the Telegraph you are to take over, or propose to take over, is in the hands of the Telegraph Construction Company?

The CHAIRMAN: And others.

Mr. J. NEWTON: I am an ordinary shareholder, and have bought one share in order to be allowed to speak.

Mr. NEWTON: I now want to ask the Chairman in what position the preference shareholders stand? Here you are issuing 250,000*l*. 5 per cent. Debentures. I already hold a small interest in 5 per cent. Debentures, and that is why I take the interest I do in the Company. I should like to know whether the new Debentures will take precedence of the 200,000*l*. already issued? and also how you can do that while your preference shareholders have no right to vote? You are practically dealing with revenue which they have a lien upon, and you are going to give it to others. I think it is contrary to common sense if it is not contrary to common law, and I do not think the Court of Chancery will allow it if the preference shareholders apply for an injunction. Therefore I do not think you should do that which you do not give the preference-holders the right to vote upon. I wish also to ask whether there has been any difficulty with the authorities of Odessa, and the line which you propose to take over. I think there has been some action on the part of the Government, which has interfered with, or retarded, or prevented the proper development of that company in the proper earning of money. I simply ask the question, as I fully approve of the taking of the Odessa line by purchasing it. It is a question of price. It must be an advantage to this Company to to get possession of all the lines in the East. If an independent Company owns that line they will not rest satisfied until they have an outlet and communication somewhere, and communications will naturally press on you at a future time with necessary arrangements and amalgamating in working agreements, and transactions of that kind. You had much better buy it up at a fair price. It is an important factor what value you are to give.

The CHAIRMAN: I think the best thing would be to put the meeting right in regard to the legal point. I think the Solicitor had better answer Mr. Newton's remarks.

Mr. BURT (the solicitor): The question that has been submitted to the Chairman is whether the Debentures now proposed to be issued would rank in priority to the existing Debentures? That, of course, could not possibly be the case. The Debentures will rank equally with the existing Debentures. The date fixed for payment will be stated in the Debentures, and that will govern the transactions between the holders of the Debentures and the Company. With regard to the other matter, the position of preference shareholders, they are, by the terms on which the shares were issued, expressly prohibited from voting at meetings, and not only was that upon the circular on which the shares were subscribed, but I believe Mr. Newton will find on the back of his certificate that he has not the right of voting at meetings. That is a binding contract between the preference shareholders and the Company, and they have no right to vote. Another thing is whether Mr. Newton, as the holder of one share, would have the right of moving a resolution.

Mr. NEWTON: No, to speak.

Mr. BURT: There is no question as to the right of speaking at any time, but as to moving an amendment, I should have to say, as on a former occasion, that Mr. Newton is not qualified to move a resolution or an amendment.

Mr. WILLIAM FORD: Before the resolution is put to the meeting I think it is due to the shareholders who differ from the previous speaker, that I, as representing a very large interest in this Company, should express my opinion upon the resolution which is now before the meeting. I have made it a point of acquainting myself, as far as possible, with the position of the Black Sea Telegraph Company. I have in my hands, or, rather, I had a moment ago, the prospectus of that Company. I have inquired into the nature of the business transacted there, and I am perfectly clear that the Directors of this Company would have been wanting in their duty to the proprietary generally, if they had not availed themselves of the opportunity which is now offered to them of acquiring this most valuable, and, in my opinion, necessary adjunct to this Company. Gentlemen, it has been said it is a question of price, and one honourable Shareholder who spoke before, for the purpose of showing a doubt as to the *bona fides* of the parties who have carried on these negotiations, adverted to the fact that it appeared to him that Directors of the Telegraph Construction Company were also Directors of this Company. I believe it is not the fact. I believe there is not a single Director.

The CHAIRMAN: One. Lord Alfred Paget.

Mr. FORD: But I venture to say they know the value of it better than any other person. I venture to say from the friendly relations that fortunately exist between our Company and the Telegaph Construction Company, that we have got it at a price less than any other persons desirous to establish a competitive Company would have obtained it for. For my own

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part, it appears to me, the price is reasonable. I think we must put our trust in our Board, who best know, from the information they have received as to the past working of this Company, and from the knowledge they have as to its prospective working, whether we should enter into this arrangement. The next question they have referred to is as to the Telegraph to Cyprus. Now, Sir, I can hardly suppose that the Directors have not taken steps to ascertain what will be the probable amount of traffic. It may not be that it will be immediate, but, Gentlemen, if you are to wait until the traffic is established to pay ten or twenty per cent., according to the opinion of some gentlemen who would not have much opportunity of acquiring it. The effect of our obtaining this will be to render competition unnecessary or impossible, and I think, therefore, as I said before—and I speak as a Proprietor having a large interest in the concern, and to whom the question of Dividend is a material one, for I speak from a dividend point of view only and simply—and I say that, in my opinion, it is greatly to the interest of the Company that such a communication should be made if, with the information that our Board have, they consider it necessary. I therefore give my unqualified assent to the proposal of the Board [applause].

A SHAREHOLDER: Will the Debentures it is proposed to issue be for five or seven years?

The CHAIRMAN: We have not quite settled that point; but I may say in answer, because I will reply to the other speakers afterwards, as you are aware we have an amount of 6 per cent. Debenture Debt, and it is our intention, when these Debentures become due, that we shall replace them at 5 per cent. Therefore we shall so arrange the present issue that we shall make them terminate about the time when we shall be able to convert them into 5 per cent. ones.

A SHAREHOLDER: Will this Cyprus matter be taken separately from the Black Sea Cable, for we might assent to the one without the other?

Mr. PRICE: I am not a large Shareholder in this concern myself, but many of my friends hold in the aggregate a very large number of Shares; and it was mainly through my recommendation that they took their Shares, so that I may be said to speak really from a feeling point of view in this matter. The last speaker referred particularly, in the first place, to the purchase of the Constantinople-Odessa Cable, and I do not think there can be two opinions with regard to that matter [applause]. I hardly thought there would have been two opinions expressed in the meeting with regard to that matter; but there has been a doubt thrown out by one speaker here with regard to the price, although there has not been a word said against the purchase of the Company. I I think myself, and I think every gentleman who is acquainted with the Eastern part of Europe must acknowledge, that it is very desirable for this Compay to get possession of that Cable. It will secure to us a very large amount of traffic from which we are at present debarred. I think the Directors will receive a very general support in their policy in that direction [Hear, hear]; and I think, further, that it is their policy in that direction which has gained them the repute they have got. There is one point which requires a little more explanation—that is, this meeting has been called to spend, not 250,000*l.*, which we are now told will be spent, but a very much smaller sum; and I think, in courtesy to the Shareholders, they are entitled to some further explanation on that matter than they have had. Now, with regard to the Cyprus question, I fully support the amendment which has been moved in reference to that matter to which the amendment refers. I think it refers solely to that, and I support it; but, with regard to the Black Sea Cable, I shall not support it. With reference to the Cyprus matter, we have a Cable, or, at least, there is one which is more than sufficient for the traffic which the Island requires, and which it is likely to require for the next twenty-five years. I do not think it becomes us, nor is it our business, to make any extensions which are not remunerative, and I do not agree with the last speaker. We should look primarily to our own interests, and if the Government want another Cable to Cyprus let them lay it, as they have recently done to some other Islands. There is not likely to be a remunerative traffic for many years from Cyprus, and I should like the Chairman to tell us whether he has any information on the subject likely to interest us, and disabuse our minds of this opinion. I should like him to tell us from what the estimated revenue is to be derived, so as to make this Cable remunerative. If he is prepared to state that he does not think this Cable will be remunerative I think we should not have it. I think the better course will be to abandon, at least for the present, the laying of the cable from Cyprus to Alexandria.

Mr. BAYNES: One word in explanation. I wish the meeting distinctly to understand this, that my suggestion for postponing for twelve months refers to the Cyprus Cable. With regard to what I said as to the Black Sea Cable, I think we ought to have a greater amount of information before we spend so large a sum; but my amendment now is with reference to this Cyprus question.

The CHAIRMAN: I think I shall be able to explain to you that your Directors are in possession of information which many of the gentlemen who have spoken cannot possibly know of. I think, and I hope, I shall be able to show you, that we have only been attending to your interests in the course we have pursued. In the first instance I will answer Mr. Marks. He speaks of taking the Cable and approves generally, as I understand, of our policy, but he suggests that the payment for the Black Sea Cable should be taken from the Reserve Fund. That simply means having no Reserve at all. It is very necessary that, as we are going on consolidating this property, we should have a Reserve Fund standing out clear and distinct from any portion of the Company's property [applause], so that in the event of anything occurring we could apply to it and put our system in order at once. I think that is a sufficient answer with reference to the Reserve Fund. Now it has been stated that Cyprus is a barbarous place. I quite admit that Cyprus, from the information we are now getting from day to day is not at present in a very high state of civilisation. But you must look at what it was, and what it no doubt will be again under this government. You must look to the enterprising spirits that have now gone to Cyprus; and we know that at the present moment there is a Telegraph there belonging to the Turks, but it takes days instead of hours to do the work. The consequence of that is that the people are anxious to telegraph but they cannot get their Telegrams despatched. I have no hesitation in saying from our experience of Telegraphs that a very large amount of capital will be invested in Cyprus. I have no hesitation in saying that Cyprus will be one of the best paying links in the whole of our system [applause]. But again then we are not doing this entirely at our own expense. We have been acting for the Government to a certain extent in meeting their requirements in these Seas, and for which they have paid a certain amount of money. We laid down for the Government a cable from Chios to Tenedos and Besika Bay. That Cable is now connected with Constantinople by the system to which I alluded. That system for a time did not quite answer because Constantinople was to a certain extent isolated, but it is now becoming profitable. It is in negotiation, and part of our proposal with regard to the Cyprus Line, that the Government virtually pay us half in meal or malt, as the saying is, something like half the cost of the Cyprus Cable. Now, gentlemen, it is all very well to speak plainly to the Shareholders who are here now, but it is not always prudent. There must be a certain amount of confidence placed in the Directors, and when negotiations are in a certain state of progress it is not always prudent for me to come here and allow those things to get into the Press. Now, I will refer to Mr. Baynes. I am always glad to have criticism, which shows there is some real interest taken in the progress of the Company, not criticism merely for the purpose of finding fault. I quite admit that we are not perfect. I think we are sometimes bound to do things which may call for criticism; but there is nothing that we do that we are not prepared to justify. Now, Mr. Baynes's policy is what may be called a standstill policy altogether. We have shewn, if he chooses to accept them, by the figures I have given as to the Black Sea Cable, the reasons why we have not taken it over before, and why we propose to take it over now. I may say that in February, when the Cable was opened after the war, there were over 3,000 messages taken; in March there were 8,000, in April 9,000, and so on, showing that there is a great amount of vitality in that system. Another point is this—the question of cost. I say most emphatically and distinctly, that had it not been for the connection which exists more or less between the Telegraph Construction Company and this Telegraph Company over which I have the honour to preside, I do not think we could have got this Cable at anything like the price we have. I say this because I know the question will be asked, and will be put to me, "Why are these people selling the Cable?" That has been put to me many times, and I simply say, "Because the Telegraphic Construction Company and the other gentlemen who went into the matter are not Cable-workers, but Cable-makers," and they have given us the full advantage which they have derived at a price at which we could not do better if we were to go all the world round for a Cable. If there have been any difficulties at Odessa we are perfectly ignorant of them. The only difficulty I understood at the time was that during the war the Russians cut the Cable, or rather it was sealed up; but beyond that I am not aware of anything on the part of the Russian Government or of the people of Odessa interfering with the working of the system. Now, the next gentleman I have to answer is Mr. Price. Mr. Price approves of buying the Black Sea Cable, but he is not in love with Cyprus. I think I have given you a very good reason for dealing with Cyprus, and have virtually answered Mr. Price's remarks [hear, hear]. Now, gentlemen, I was blamed also for not giving you sufficient information, but I read you the figures, and, if the meeting would wish it, I have no objection to read them again. I say the cost of the Black Sea Cable is 74,000*l.*; the cost of the Cyprus Cable from Larnaca to Alexandria will be about 60,000*l.*; (I am giving you the extreme prices) the cost of the Land lines will be about 16,000*l.*; the Stations will be about 5,000*l.*; and the cost of ships engaged in the work about 16,000*l.* These are our own ships. I have also referred to the system of lines which we may require to carry out by-and-by from Tripoli in Africa to Malta, and to certain Red Sea extensions which is put down at 55,000*l.* Then there is the balance for surplus Cable and stores of about 23,000*l.*, which makes up the 250,000*l.* that we propose to issue. As I said before, it is just possible that, in addition to this 250,000*l.*, in the event of Turkey wishing this Company to connect Jeddah with our system in the Red Sea, an additional 50,000*l.* may be required. But if that is required, as I before said, we shall show you it is in the interest of the company it should be connected. Therefore, with these remarks, I think I have made things pretty clear.

Mr. ROBERTS: After the explanation of the Chairman that the Government will give us half the amount I am quite satisfied [hear, hear].

The CHAIRMAN: Well, Mr. Baynes, there is no seconder to your amendment.

Mr. HALL: I will second it.

A SHAREHOLDER: I should like to ask the Chairman if the Turkish Government would not sell the existing line to Cyprus?

The CHAIRMAN: In answer to that I may say I had a very interesting letter from Cyprus two days ago. I may say that when this thing came up, and Cyprus became annexed to England, or rather was taken possession of, we sent a confidential agent, whose residence is at Athens, to report to us. His reply is that the Turkish Telegraph is not a Telegraph at all, that at the moment it is not in order, and is unreliable in every way. It takes days, and sometimes weeks, instead of hours, as would be the case if our system were laid.

The SHAREHOLDER: I am satisfied, sir.

The amendment on being put to the meeting only received the support of four votes, and was declared lost, the original resolution being put and carried almost unanimously.

The CHAIRMAN: That is the whole of the business of the meeting.

Mr. LEIFCHILD: Before you separate I beg to propose a vote of thanks to the honourable Chairman for his able and impartial conduct in the chair [applause].

A SHAREHOLDER: I beg to second that.

The motion was cordially agreed to.

The CHAIRMAN: Gentlemen, we are always glad to give you full information, and I always found the great body of our shareholders supporting the policy of your Directors when it is put before you in a fair and businesslike form [applause].

The proceedings then terminated.

GUTTA-PERCHA AND INDIA-RUBBER.—According to the account of imports and consumption supplied by the *Economist*, 16,150 cwt. of gutta-percha, valued at 148,812*l.*, and 93,922 cwt. of caoutchouc, valued at 825,539*l.*, have been imported in the seven months ending July 31 in the present year. These quantities show a notable increase over the corresponding imports in the year 1877, excepting as regards the money value of the caoutchouc.

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NOTES.

Economy of Zinc Consumption in Batteries.—In another column will be found a communication from Mr. Desmond FitzGerald, M.S.Tel.E., in which, for the first time, is given a general formula for calculating the zinc consumed in a battery under any given electrical conditions.

Collision Averted by Use of the Electric Light.—The ship *Faraday*, when passing through a fog off the Banks of Newfoundland in its last voyage, narrowly escaped a collision with an emigrant ship, which was only perceived in time by the electric light used on board the former.

Curious Magnetic Effect.—Donati Tomasi passes a current of steam, under a pressure of five or six atmospheres, through a copper tube of two or three millimetres diameter. The tube is coiled spirally around a small iron cylinder, which becomes so strongly magnetic that a steel needle placed at some centimetres distance is powerfully attracted. The magnetism continues as long as the current of steam is maintained.—*Les Mondes.*

A Telegraphic Heroine.—Mademoiselle Dodu, head of a French telegraph station, has been decorated with the Legion of Honour for the patriotic crime of having intercepted a despatch between two German generals during the Franco-Prussian war. May our lady-telegraphists never have a chance of earning like distinction! Mademoiselle Dodu—not a very romantic name for a heroine, *Miss Plump!*—is, we believe, one of three ladies who enjoy this distinction, the other two being Rosa Bonheur and Lady Pigot.

Telegram Code.—We understand that Dr. Ager proposes to issue a second edition of his "Telegram Code" about the end of the present month. The book has been thoroughly revised and very largely extended. Many merchants who have used the Code for three years have given hints that have enabled the compiler to increase the number of sentences to nearly 50,000. The Code words have been revised by a telegraphist of long standing, connected with one of the leading telegraph companies. Any additions which may be thought desirable to be made to the Tables at the end of the Code will receive attention if sent within the next few days, addressed to Dr. Ager, 50, Wellington-road, Stoke-Newington.

Electric Alarum Safe.—Mr. Max Koloseus, of New York, has recently patented a safe which is ingeniously connected with a battery and alarum apparatus, so as to render the drilling, picking, forcing, or removal of the safe almost impossible without detection. The outer wall of the safe is insulated from an inner plate, covering the sides and door; and the safe stands upon plates inserted in the floor. On tampering with, or attempting to remove the apparatus, the battery current is either broken or shunted, and a relay is caused to act, through which the alarum is influenced and continues ringing until stopped. The alarum apparatus can be placed in any suitable place about the house, in the night-watchman's room, police-station, &c. The safe in question does not differ in appearance from any other.

Maiche's Diaphragm.—L. Maiche proposes to correct the *timbre* of the telephone in the following manner:—"I stretch before the magnetized bar a caoutchouc membrane not exceeding four centimetres in diameter, with a thickness of one millimetre. To the centre of this membrane I glue a disc of tinned iron of at least the same thickness, having a diameter of three centimetres, and I cut the caoutchouc, on the side towards the magnet, over a diameter a little greater than that of the magnet. The caoutchouc being well stretched, it can be placed at less than one millimetre from the magnet. I thus combine two seemingly opposite conditions:—1, a thickness of iron sufficient to react properly upon the magnet and to develope currents of sufficient intensity; 2, a vibratory sensibility which enables me to collect extremely feeble sounds; moreover, the voice which is heard is precisely that of a person speaking at a distance of a few metres. The *timbre* undergoes no change, all the gradations being preserved in the most perfect manner.—*Les Mondes.*

The Post Office Telegraph Clerks in Dublin.—We reproduce the following from the *Freeman's Journal*:—"A curious fact was elicited yesterday (August 16) by a question asked of the Postmaster-General by Mr. O'Byrne, for Mr. Gray. On the 23rd of last month a memorial to the Postmaster-General by the telegraph clerks in Dublin, complaining that they were not placed on an equality with their brethren in the great English towns, was handed to the authorities here. In ordinary course it should have reached the hands of Lord John Manners on the 24th. But it appears it has not reached him at all. The question is, has it been suppressed, and, if so, by whom? This is a very serious matter, and calls for explanation. If the chiefs of an office can suppress a memorial adopted by their officials to the head of the department, what protection have the latter? They cannot appeal to the Press, under pain of dismissal, and, in fact, they are left helpless. We would like to know, too, why the clerks in Dublin should not be paid the same rate for the same work as in Manchester or Liverpool. It appears to us that the Department in Dublin wants an overhauling.

Motions Produced by Dilute Acids on some Amalgam Surfaces. Abstract of paper read 15th Aug., 1878 (section A), B.A. meeting, at Dublin, by Robert Sabine.—The author finds, when a drop of very dilute acid is placed upon the clean surface of a newly-filtered amalgam of some metal which is positive to mercury, that the drop does not lie still, as it would do upon pure mercury, but sets itself into an irregular, jerky motion. This is the case with copper, zinc, antimony, tin, and lead amalgams; but if, instead of these amalgams, those of platinum, gold, and silver are used—these latter metals being negative to mercury—the drop of acid-water lies quite still. The acids tried were sulphuric, hydrochloric, oxalic, and acetic, which behaved similarly, but in different degrees. When the experiment is made in an atmosphere of oxygen, the movements upon the amalgams of the positive metals are increased; but, in hydrogen, carbonic acid, nitrogen, and coal-gas, the motions are instantly arrested. The author concludes that the motions result from an alternate play of deoxidation of the mercury underneath the acid by electrolysis due to the currents of small floating particles of the positive metal, causing the drop to contract, and of oxidation of the surface outside the acid-drop, causing it to expand.

The Detonating Voltameter.—E. Venelle, in *La Correspondance Scientifique*, describes a simple piece of apparatus which gives curious results. It may easily be constructed, and we think the following will serve the purposes of our readers for experimental work. Take two similarly-sized test-tubes, and cut them short, making tubes of ¾ in. diameter, and 2 or 3 inches long. Fit the mouth of one with a cork pierced with three holes, two of these for conducting wires, one for a small glass tube to go through. At the end of the conducting wires within the tube solder platinum plates; the other ends are connected with binding screws. The second tube is fitted with a cork with one hole, through which the previously mentioned small glass

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tube which supports the first tube in an inverted position is fixed, and also a small air-hole. The upper and inverted tube is filled with acidulated water (1 of $H_2\,SO_4$ to 10 of $H_2\,O$). The binding screws are then connected with a battery equivalent to not less than 50 Bunsen's elements. Gases are rapidly given off, and, when the tube is nearly full, the gases spontaneonsly combine and illumine the tube. With 30 elements the gases are given off till the level of the water is at the bottom of the platinum plate, when the level commences to oscillate between the bottom and the top. With less than 30 elements decomposition takes place, but not recombination nor oscillation; the whole jar, in fact, is filled with gases. These phenomena are said to be due to polarisation, and to be obtainable with electrodes of various metals.

A New Cheap and Self-Generating Disinfectant.—Under this title Dr. John Day, of Geelong, Australia, recommends for use in civil and military hospitals, and also for the purpose of destroying the poison germs of infectious diseases, a disinfectant composed of one part of rectified oil of turpentine and seven parts of benzine, with the addition of five drops of oil of verbena to each ounce. Its purifying and disinfecting properties are due to the power presumed to be possessed by each of its ingredients of absorbing atmospheric oxygen and converting it into either peroxide of hydrogen or ozone. Articles of clothing, furniture, wall paper, carpeting, books, newspapers, letters, etc., may be perfectly saturated with it without receiving the slightest injury; and, when it has once been freely used on any rough or porous surface, its action will be persistent for an almost indefinite period. This may at any time be readily shown by pouring a few drops of a solution of iodide of potassium over the material which has been disinfected, when the peroxide of hydrogen, which is being continually generated within it, will quickly liberate the iodine from its combination with the potassium, and give rise to dark brown stains. It may be applied with a brush or a sponge, or, if more convenient, as is the case with certain articles, such as books, newspapers, and letters, it may be simply poured over them until they are well soaked; they may then be allowed to dry, either in a warm room or in the open air. It is hardly necessary to say that this disinfectant should never be made use of in the neighbourhood of fire or artificial lights for fear of accidents from ignition of the vapors arising both from the benzine and turpentine.

Gilding on Glass.—A new process by M. Dodon is thus given by the *Moniteur de la Céramique.* Gold, chemically pure, is dissolved in aqua regia (1 part nitric and 3 parts hydrochloric acid). The solution effected, the excess of acids is evaporated on a water bath till crystallisation of the chloride of gold takes place; it is then taken off and diluted with distilled water of such quantity as to make a solution containing one gramme of gold to 200 cubic centimeters of liquid; a solution of caustic soda is then added until the liquid exhibits an alkaline reaction. The solution of gold is now ready for reduction. As a reducing agent an alcoholic solution of common illuminating gas is used. This is prepared by simply attaching a rubber tube to a gas jet, and passing the current of gas for about an hour through a quart of alcohol. This liquid (which should be kept in a closed vessel) is added in quantities of from two to three cubic centimeters to 200 cubic centimeters of the alkaline solution of gold before mentioned; the liquid soon begins to turn to a dark green colour, and at length produces the metallic layer of gold of known reflecting power. As an improvement on the process, as well as for convenience in executing it, there may be added to the alcoholic solution of gas an equal quantity of glycerine (28° to 30° Baumé), previously diluted with its own volume of distilled water. If the gold employed is an alloy, the foreign metals must in all cases be first removed, and especially the least traces of silver, because the very smallest quantity of this metal totally prevents the regular and uniform deposition of the gold. The bath thus once prepared, it is proposed as a method of gilding mirrors, but also for all the articles of various branches of industry where this process of gilding could be used with success and to advantage, such, for instance, as boxes, necklace beads, candlesticks, glass ornaments, frames of table mirrors, cups, saucers, spoons, lanterns, and reflectors, and for objects generally in glass or crystal that are capable of being completely gilded.

Motion of Electricity in Insulated Telegraph Wires. By G. Kirchhoff.—Assuming that the induction effects produced by alterations of the current intensity may be neglected against the influence of the charges of an underground telegraph wire, Sir W. Thomson has referred the propogation of the electricity therein to the same laws as the conduction of heat. G. Kirchhoff developes this relation in connection with the equations developed by Helmholtz respecting the components of the current density ($u = -\lambda \frac{\partial \phi}{\partial x}$, &c., where λ denotes the conductivity) and of the electrostatic moment dependent on the dielectric polarisability ($a = -k \frac{\partial \phi}{\partial x}$, &c.), if ϕ denotes the electrostatic potential, which is a function of x, y, z and consists of three parts, arising—first, from the free electricity in and upon the conductor; secondly, from dielectric polarization; and, finally, from the double electric layer at the boundary surfaces of heterogeneous conductors. From the calculations, which cannot be given in abstract, it follows that $\Phi = e^{\beta z}\Big(C \cos.\ (n t + a z) + C' \sin.\ (n t + a z)\Big) + e^{-\beta z}\Big(D \cos.\ (n t - a z) + D' \sin.\ (n t - a z)\Big)$, which equation represents two passages of waves in opposite directions along the z axis of the wire, in which the height of each wave as it moves forward diminishes correspondently to the value β. The period for ϕ, according to the time, is $\frac{2\pi}{n}$; β and a are given by the equations

$$\beta^2 - a^2 = \frac{2\lambda}{\lambda_1 \rho_1^2 \log \frac{\rho_2}{\rho_1}}, \qquad \beta a = \frac{n\mu}{\lambda_1 \rho_1^2 \log \frac{\rho_2}{\rho_1}},$$

where ρ_1 and ρ_2 are the internal and external radius of the gutta-percha sheath, λ and λ_1 the conductivities of it and the wire, $4\pi\mu = 1 + 4\pi k$ the constant of dielectricity of the gutta-percha. Therefore the velocity of propagation of the waves increases with the conductivity of the gutta-percha, simultaneously with which their height diminishes as they travel onwards. If the conductivity of the gutta-percha $\lambda = 0$, then becomes

$$a = \beta = \sqrt{\frac{n\mu}{\lambda_1 \rho_1^2 \log \frac{\rho_2}{\rho_1}}}.$$

If the wire is infinitely long, then (if, for $z = 0$, $\phi = \cos.\ n t$) is $\phi = e^{-\beta z} \cos.\ (n t - a z)$. Further, the following case is discussed: That the wire possesses the length l, but has its termination connected with one of the coatings of a condenser, the other side of which is led away to earth. For the calculation in question, as well as the rest of the working, which cannot well be given in abstract, we must refer the reader to the original memoir.—*Beiblätter zu den Annalen der Physik und Chemie.*

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ON A MODIFICATION OF MANCE'S METHOD OF MEASURING BATTERY RESISTANCE.

BY O. LODGE, D.SC.

[CONTINUED FROM P. 137.]

Modification of Mance's Method.—There is also a practical objection to the ordinary form of Mance's method, not relating to its essentials, but to its sensibility and convenience, which the modification is intended entirely to remove. It is this:—The galvanometer in g, whose function it is to indicate any change in the current in that branch, has always a certain current passing through it; and its needle is, therefore, deflected more or less, according to the sensibility of the galvanometer; but the current produced by an ordinary cell whose resistance one wishes to measure is usually such as one does not care to pass through a delicate instrument, even if the excessive deviation it produces be corrected by external magnets. A rough galvanometer is, therefore, generally employed, and the needle is brought back reasonably near its mean position by magnets placed near it. But the needle being thus constrained by immersion in a powerful magnetic field, is by no means under favourable conditions, and only comparatively large changes in the current can be indicated by it. To remedy this defect and to make the method a *null* one, my first idea was to use a differential galvanometer and to send through its second wire a current from an auxiliary battery equal and opposite to the current produced in its first wire by the cell whose resistance is being determined, so as really to neutralise instead of merely to overpower its action on the needle. Or, without using a differential galvanometer, we may balance the electromotive force in the galvanometer circuit by means of an auxiliary closed battery circuit after the manner of Poggendorff. If either of these arrangements be adopted, we can use a sensitive Thomson's galvanometer, and its needle may be as nearly astatic as we choose. But it is not easy to get the two batteries under such similar conditions that they shall constantly oppose one another exactly; and though these arrangements may be useful in some cases, they are rather complicated, and the adjustments somewhat difficult to make.

The next alteration which suggested itself consisted in interposing a condenser in the galvanometer circuit (see Fig. 11*). This effectually prevents any continuous circulation of electricity in that branch; and the galvanometer therefore remains at zero after the condenser has acquired it full charge; but any variation in this charge is indicated by a throw of the galvanometer-needle proportional to the amount of variation. The quantity of electricity flowing into or out of the condenser through the galvanometer-coil will be equal to the variation of potential, Y, taking place between its terminals, multiplied by S, its statical capacity; and the throw of the galvanometer-needle a will be proportional to this quantity multiplied by the galvanometer-constant Γ, which depends directly on the number of turns of wire on it. The resistance of the galvanometer is quite immaterial. If H is the strength of the magnetic field in which the needle hangs, and T the time of a complete oscillation of the needle in that field, we have

$$\sin\frac{a}{2}=\frac{\pi\,\Gamma\,S\,Y}{H\,T}. \qquad (3)$$

By using, therefore, a galvanometer with a very large number of turns, and a condenser of great capacity, one can increase the sensitiveness of the method to any extent.

The investigation of the distribution of currents throughout the circuit becomes very simple now that there is no continuous current through the branch g. The connexions are shown in fig. 11, where AC is the branch r, whose resistance can be changed at pleasure from infinity to something near zero. Let A, B, C, D, be the potentials of the four corners; let d be the resistance of the battery we wish to measure, ϵ its electromotive force, and u the strength of the current passing through it. We want the difference of potential B − D to be wholly independent of the potentials of A and C, which will be altered by changing r. Now as there is no current through g, we have the same current passing through b as through a—that is,

$$\frac{A-B}{a}=\frac{B-C}{b}, \text{ or } B=\frac{Ab+Ca}{a+b};$$

similarly

$$D=\frac{(A-\epsilon)c+Cd}{c+d};$$

hence

$$B-D=\frac{(A-C)(bd-ac)+\epsilon c(a+b)}{(a+b)(c+d)}, \qquad (4)$$

which shows that the difference of potentials between the terminals of the condenser is independent of the potentials A and C as soon as the condition $bd-ac=0$ is satisfied.

We may conveniently write the above expression in terms of the strength of the current u passing through the battery d; thus, since $A-C=\epsilon-(c+d)u$,

$$B-D=\frac{(ac-bd)u+\epsilon b}{a+b}. \qquad (4a)$$

So, if $ac=bd$, the difference of potential B − D is quite independent of the current through the cell (except in so far as the electromotive force ϵ depends upon it) and is equal to $\frac{\epsilon b}{a+b}$ or $\frac{\epsilon c}{c+d}$, which are the same thing.

The current u is of course dependent on the resistance r of the branch AC, being

$$u=\frac{(a+b+r)\epsilon}{(a+b)(c+d)+r(a+b+c+d)}; \qquad (5)$$

so we may also write the above difference of potential in terms of this resistance r, thus:—

$$B-D=\epsilon\cdot\frac{(a+b)c+r(b+c)}{(a+b)(c+d)+r(a+b+c+d)}. \qquad (4b)$$

All the differential coefficients of this with respect to r contain the factor $ac-bd$; consequently when this factor vanishes this quantity is independent of r.

Conditions for Sensitiveness.—To find out what are the values of a, b, and c which give the greatest sensitiveness, we can subtract the value of B − D when r is infinite from its value when r is zero, and can make this quantity a maximum when the condition $ac=bd$ is nearly fulfilled. The quantity which has to be a maximum is

$$y=(B-D)_0-(B-D)_\infty=\frac{\epsilon(ac-bd)}{(c+d)(a+b+c+d)}. \qquad (6)$$

The resistance d is supposed to be given; so let us define the others with reference to it, putting

$$c=\lambda d,\ a=\mu d, \text{ and } b=\lambda\mu d=\lambda\mu(1-z)d,$$

where z is a small quantity; then the above quantity becomes

$$y=\frac{\lambda\mu z\epsilon}{(\lambda+1)^2(\mu+1)} \qquad (6a)$$

Considered as a function of λ, this is a maximum when $\lambda=1$; it has in fact the same value whether $\lambda=n$ or $\frac{1}{n}$. Considered as a function of μ, it has no maximum, but it is greatest when μ is infinite, though it does not increase fast after μ is tolerably large; the curve is, in fact, a rectangular hyperbola with asymptotes $y=1$ and $\mu=-1$; and 1 is its greatest value for positive values of μ. Accordingly the most sensitive arrangement is obtained when $\lambda=1$ and when $\mu=\infty$—that is to say, when c is equal to d (the resistance to be measured), and when a and b are equal and as large as convenient. When these arrangements are made, the maximum value of y, or the change in the difference of potential between the terminals of the condenser brought about by depressing the key, is, when c is nearly equal to d,

$$Y=\tfrac{1}{4}\epsilon z \text{ or } =\frac{\epsilon}{4}\cdot\frac{c-d}{d}; \qquad (7)$$

and this is the quantity to be inserted in equation (3).

The sensitiveness is evidently directly proportional to the electromotive force of the cell: but it is independent of its resistance; *i.e.* a high resistance is measured with as great proportional accuracy as a low one. But it must be remembered that when the resistance to be measured is great, the resistances a and b should be as great also; if they are not as great as d, the sensitiveness falls off very appreciably. But, as said before, there is really no limit to the sensitiveness of the method; for the size of the condenser and the length of wire on the galvanometer may be increased to any extent.

Practical Details.—The condenser I have used is a small standard one with the dielectric of mica; and it has a capacity of slightly over one micro-farad. The galvanometer is a Thomson astatic by Elliott, with a resistance of about 7,000 ohms. The two branches a and b of the resistance-coils, forming the equal arms of the bridge, were 1,000 ohms each, being the largest resistance conveniently available in the box of resistance-coils used. But when the resistance to be measured is large (say over 500 ohms) it is better to have a and b greater than this; and they may then be made of Muirhead's carbon-paper (fig. 12). A strip two feet long by half an inch broad will have a resistance of about 1,400 ohms; and the galvanometer terminal B may be connected with its middle so as to divide it into two halves representing a and b. Exact equality in the two arms is not essential, as it is easy (and, indeed, generally advisable) to eliminate any errors of this sort by a method analogous to double weighing. Connect a and b to a commutator in such a way that it is easy to interchange them end for end (see fig. 4), and balance the resistance d by the coils c; then interchange a and b and

* *Vide* Supplement, Aug. 10.

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balance again; this time we may require an amount c'. Then it is easy to see that $d = \sqrt{(cc')}$, whatever the ration of a to b; for in the first case we have $d : c = a : b$, and in the second $d : c' = b : a$. If c and c' are nearly equal, their arithmetic mean may be taken instead of their geometric, as being easier to calculate.

Use of a Double-wire Galvanometer as an Electrometer.—When a differential galvanometer, or a galvanometer with two long fine wires wound side by side, is employed, a separate condenser is not absolutely necessary; for the galvanometer itself has a certain capacity, and in order to charge one of its wires up to the potential B, and the other down to the potential D, a certain quantity of electricity must flow into the one wire and out of the other, and any variation in this quantity will affect the needle (though the galvanometer-constant has only half its ordinary value). Even when a separate condenser is used the capacity of the differential galvanometer may be taken advantage of, by connecting the terminals of the condenser to its two middle screws (instead of joining them directly to each other by a wire and inserting the condenser as in fig. 11), so that both condenser and galvanometer get charged instead of only the condenser. The defect of this method is, that the insulation between two silk-covered wires is not very perfect, and there is a slight leakage, which maintains a slight continuous deflection of the needle when the two outer screws are joined up to a battery; moreover, the statical capacity of an ordinary fine-wire differential galvanometer is not very great.

But I think it may be often convenient to use a double-wire galvanometer as an electrometer in this way. For instance, rapidly to compare the electromotive force of any number of cells, join them up to the outer screws of the galvanometer with disconnected wires one after the other; the kick in each case measures the electromotive force of the cell. It might also be used to measure very high resistances. It is quite possible, and indeed very probable, that this method has been suggested before.

[TO BE CONTINUED.]

CORRESPONDENCE.

ON THE RELATION BETWEEN THE ELECTROMOTIVE FORCE ACTING IN A VOLTAIC CIRCUIT, AND THE WEIGHT OF ZINC CONSUMED IN THE BATTERY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The question propounded by your correspondent "C. E. B." is somewhat indefinite, but merits, I think, a more accurate answer than it has hitherto received, since it involves points of very considerable theoretical and practical importance.

This question is stated as follows:—"Is not the increase of electromotive force of one battery over another obtained chiefly, if not entirely, by a more rapid consumption of zinc? Take, for example, a Grove and a Daniell; the former is said to have twice the power of the latter. Does it not consume twice as much zinc as the Daniell in each unit of time?"

To answer the particular question it is necessary to assume certain conditions which are not specified, as, for instance:—

1. The current is maintained constant;

Or, 2, the resistance of the circuit is constant.

Moreover, to answer the general question, we require to take one of the two following cases:—

(*a*). The total E.M.F. is increased by augmenting the E.M.F. of each couple in a battery of a given number of cells,

Or (*b*) the E.M.F. is increased by augmenting the number of cells in series.

Thus the one question resolves itself into four questions, the answers to which are as follow:—

I (*a*). The consumption of zinc is not increased by any augmentation of the E.M.F., although the current traverses a resistance necessarily increased in the same ratio as the E.M.F.

I (*b*). The consumption of zinc is increased proportionately to the E.M.F.

II (*a*). The consumption of zinc is increased proportionately to the increased E.M.F., or proportionately to the current.

II (*b*). The consumption of zinc is proportionate to the square of the ratio between the increased and the original E.M. Forces.

Mr. L. A. Davies—in the first sentence of whose communication the words, "If we wish to double the E.M.F." have evidently, by a *lapsus pennæ*, been written for "If we wish to double the current"—has taken the last case; and his answer, under the conditions specified, is correct.

In regard to Mr. A. C. M. Weaver's letter, I may state that I am answerable for the formula $Z = \frac{E^2 \times 16}{R}$ grains per hour, given by him, but not for its application to any battery other than Daniell's. The case taken by him is that indicated by 2 (*a*), and his answer is therefore incorrect.

My general formula for the consumption of zinc in a battery is the following:—

$$Z = \frac{E^2}{Re} \times 17{\cdot}3 = \frac{E}{R} n \times 17{\cdot}3 = \frac{IE}{e} \times 17{\cdot}3 = In \times 17{\cdot}3,$$

Where Z = weight of zinc consumed, in grains per hour,
E = the total E.M.F in volts,
R = the resistance in ohms,
I = the current in Vebers per second,
e = the E.M.F. of each cell of the battery,
and n = the number of cells in the battery.

The economy—so far as regards the consumption of zinc—of employing cells of high E.M.F. is, perhaps, best seen in the case of a constant current through a constant resistance—*e. g.*, when a given current is obtained through a telegraph circuit with cells of lower and of higher E.M.F. In this case the consumption of zinc is inversely as the E.M.F. of each of the couples of which the requisite battery is made up; or, in other words, the economy of zinc is directly as the E.M.F. of the cell employed.

It may be useful to give an example of the application of the formula $Z = \frac{E}{R} n \times 17{\cdot}3$ *grains per hour* to the four cases specified above. According to the suggestion of "C. E. B.," I will take the Daniell and the Grove cells, and *suppose* that their electromotive forces are respectively 1 and 2 volts. Let our initial current be that of a battery of five Daniells in series acting through a total resistance of 100 ohms.

Here we have E = 5, R = 100, and n = 5.

The current is $\frac{E}{R} = \frac{5}{100} = {\cdot}05$,

and the weight of zinc consumed per hour will be:—

$$Z = {\cdot}05 \times 5 \times 17{\cdot}3 = 4{\cdot}32 \text{ grains.}$$

I. (*a*). Instead of the five Daniells, let us now use five Groves. We shall now have E = 10, n = 5, and, since $\frac{E}{R}$ must be ·05, R = 200.

$$\text{Thus } Z = \frac{10}{200} \times 5 \times 17{\cdot}3 = 4{\cdot}32 \text{ grains per hour.}$$

I. (*b*). Let us now double the initial E.M.F. by doubling the number of Daniells' cells in series. We shall have

$$E = 10,\ R = 200,\ n = 10,\ \frac{E}{R} = {\cdot}05, \text{ and}$$

$$Z = \frac{10}{200} \times 10 \times 17{\cdot}3 = 8{\cdot}65 \text{ grains per hour.}$$

II. (*a*). Using five Groves through the initial resistance of 100 ohms, we have

$$E = 10,\ R = 100,\ n = 5,\ \frac{E}{R} = {\cdot}1, \text{ and}$$

$$Z = \frac{10}{100} \times 5 \times 17{\cdot}3 = 8{\cdot}65 \text{ grains per hour.}$$

II. (*b*). Lastly, with ten Daniells acting through the initial resistance of 100 ohms, we have

$$E = 10,\ R = 100,\ n = 10,\ \frac{E}{R} = {\cdot}1, \text{ and}$$

$$Z = {\cdot}1 \times 10 \times 17{\cdot}3 = 17{\cdot}3 \text{ grains per hour.}$$

The last value equals 4·32 × 4—*i. e.*, the original consumption of zinc multiplied into the square of the ratio $\frac{10}{5} = 2$ of the increased to the initial E.M.F.

DESMOND G. FITZGERALD.

GUM BALATA.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of last week I see that "balata, a substitute for gutta-percha," forms the subject of one of your interesting "Notes."

I just wish to point out that this substance is not really so new as Dr. W. Riegler would lead us to believe.

In 1862 a bottle of the juice yielding this substance was put into my hands for analysis. The bottle was protected by being corked with the coagulated juice.

This substance has no properties in common with india-rubber, and I am not aware of its being applied as a substitute for caoutchouc, although, no doubt, small quantities of it may, like gutta-percha, be incorporated with india-rubber and vulcanized.

Another fact, not in accordance with Dr. Riegler's observation, is that it softens much more readily than manufactured gutta-percha, and hence is not likely to replace this substance at all;

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its only use seems to be confined to the production of inferior gutta-percha goods. It is certainly not a better insulator than gutta-percha.

When I was in Demerara I was told that immense supplies of this substance could be obtained if it was required. No one in his senses could possibly mistake balata for gutta-percha, and yet Dr. Riegler says that it is shipped from Guiana and sold for gutta-percha.

It has been used in this country for some years, and I believe was first practically turned to account by the Silvertown India Rubber Company.—Yours truly,

THOMAS T. P. BRUCE WARREN,
Analytical Chemist to the India Rubber, Gutta Percha, and Telegraph Works Company, Limited.

Aug. 19, 1878.

THE TELEGRAPHISTS' FUTURE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Although it is universally acknowledged by all telegraphists in the service of the different private companies that an arrangement ought long since to have been arrived at for securing eventually some species of provision or pension when old age or infirmity may render a continuity of service impossible, no one seems to have considered it worth while to take the matter up in earnest. The question has often been raised, but beyond exciting a little interest amongst a few, it has gone no further.

If you will open your columns to us I feel sure that the widespead circulation of the *Electrician* could be made *the* medium through which the matter may be thoroughly ventilated, and lead to the formation and establishment of a "provident fund;" and, although it requires a more powerful pen than mine to do justice to the cause, I shall be amply satisfied if the remarks I make serve to sufficiently awaken the interests of all concerned, and bring forth their expressions to bear on the argument.

Cable companies are all young, the oldest dating its existence from twelve to fourteen years back, yet many of their respective staffs are composed of men to whom the rapidly approaching future is a matter of earnest consideration and anxious concern; and since, from the very fact that the companies exist from so recent a date, we can have no example or precedent for assuming that, in case of old age or infirmity rendering an *employé* incapable we may expect any provision or pension from them, nor, as the matter stands, is it reasonable to expect any. What assistance the directors would eventually give to any fund is a matter for *their* decision, and it rests to be considered whether such assistance, even presumedly given, would not be subordinate to their generosity rather than to any obligation on their part, seeing that they are considered free from such obligation by reason of the successive and comparatively liberal recompense paid for work done during an *effective service.* That it would be to their interest to give every assistance to the formation of a fund is undeniable; because the *employés*, certain of a future pension, would endeavour to remain in the service, would be less liable to give a cause for removal, seeing that they may possibly risk losing the sums they have paid into the fund.

Provident clerks can, in proportion to their classification, afford to put by *something* for the rainy day, and *all can* do so if they *will*, because, considered impartially and equitably, the respective classifications, combined with the many indirect emoluments enjoyed by all, in the shape of quarters' allowances, messes, medical advice, &c., are sufficiently liberal to admit of the *principle* of saving. To these classifications there is, of course, an extreme limit, calculated rationally, according to the expensiveness, &c., of the post; many have already reached this limit, and, inasmuch as all cannot be superintendents, electricians, or clerks in charge, it follows that a large percentage must remain for a considerable time in their respective classes, as the proportion of new stations opened is very small, and the remaining chances of promotion to the above posts extremely slender, and it would be absurd to suppose that the companies could afford to periodically raise these classes, simply because a lengthy service can be urged as a reason for consideration.

Now, then, we may say we have our present position face to face with our future prospects, and, if we are to reap any real benefit from a clear knowledge of our situation, we must rely entirely on the principle of "Self Help."

Let us study the question as to the *utility* of the proposed fund.

Up to what age can a telegraphist hope to work? Of actual operatives we have no precedents, as none, or very few of us, have passed beyond a middle age. We must, therefore, judge from the nature of the service.

Our managers are responsible for ensuring a continual service, which, even although it may cease or diminish at night time, does not lessen the eventualities for which they must be constantly and hourly prepared.

Our electricians and their assistants, besides frequently being overwhelmed by responsibilities, are continually exposed to every imaginable peril, from rapid changes of climate, exposure to all weathers, necessary expeditions, frequently in dangerously small craft, and subject to every bodily and mental suffering.

In the offices, although a more sedentary life is led, we find our clerks obliged to be ever disposable, night and day, for the exigencies of their work. No invariable service can be calculated upon, and consequently it is impossible for them to attain that regularity in their functions and habits so necessary for retaining perfect health. But, as a rule, we *are* healthy, and, as a rule, telegraphists die hard. In fact, I am almost persuaded that when an old hand *does* become entirely incapacitated, it will be that his existence has ended simply because telegraphy is to us a second nature, and in reality we eat, drink, live, marry, and die by telegraph!

However, this is hypothetical. What we have to deal with is a future as yet without precedents. In every Government telegraph service a provision is made for pensions. In some few cases, the whole of the means are supplied by the Government, without the *employés* ever contributing; in others, the funds are raised equally from both; and, with the remainder, the *employé* alone subscribes to the fund, and is bound to leave a percentage on his pay for securing himself a pension.

To this latter category we should belong, and subscriptions, subject of course, to certain details, should be made obligatory by the companies.

Before proceeding further, however, it is advisable to give some idea of the pay to officers and clerks in some of those foreign administrations where obligatory subscriptions are exacted and willingly paid, and, as there is but very little difference in the salaries paid by all countries, I will restrict my remarks to those with whom I am more intimately acqainted.

In the Italian service the appointments commence at 800 francs per annum, rising rarely higher than 4,000, and to a maximum of 8,000 francs, which is the pay of the Director-General. On these sums the following percentages are retained:—Appointments under 800 francs, one per cent. per annum, from 800 to 1,200 two per cent., from 1,200 to 2,000, three per cent.; increasing one per cent. for every 1,000 francs up to nine per cent., the amount retained on the Director-General's salary.

In Greece the lowest appointment is 850fr. per annum, and the highest (save that of the Director-General's) 2,500 francs; yet all classes indiscriminately relinquish in favour of their pensions 7·5 to 10 per cent. per annum; the former being the unmarried, the latter the married clerks' contributions.

Now, if *employés* on these salaries can afford to pay such percentages for securing a pension, surely every single clerk in the different private companies' service can do the same; and it only remains to be seen whether such percentage should be a fixed one for all salaries, as in Greece, or progressive, as in the Italian service. This, however, is a question of advantages.

In Greece, after twenty years' service, two-fifths of the salary is allowed, and, after twenty-five years' service, half the actual pay a clerk may be in receipt of is accorded, and this sum is continued at his death to the widow. These favourable terms are, of course, the result of the higher scale of contributions, which, I repeat, are deducted by the administration when the salaries are paid, placed in the treasury, from whence the pensions are duly and regularly paid.

Besides this, there is a special pension fund at the National Bank, to which, although contributions are not obligatory, nine-tenths of the *employés* subscribe. The contributions are from 45f. to 150f. per annum, for a period of not less than twelve years, and the pensions accruing from this range between 500f. and 1,250f. This fund has already a capital of over 2,000,000f. The wives of *employés*, by one single payment, can also draw a fixed pension after the lapse of twelve years.

In Italy the benefits are proportionately more limited. After twenty-five years' service the recipient is entitled to five-eighths of his actual pay at the date of retirement, and a forty-years' service entitles him to four-fifths, the minimum pension being 150f. per annum, the maximum 6,500f.

From these two examples it would appear no difficult matter for us to calculate the necessary capital required, and for fixing the contributions and period of service for securing to every *employé* an adequate pension.

A committee might be formed, composed of members from every company, so that one fund might serve for all, and, in order to raise a capital, some arrangement might possibly be arrived at whereby those who desire to deposit a fixed calculated sum might have a past service, say of from four to ten years, considered as counting towards their pension.

Can I hope these feeble efforts will bring forth any good results?—I remain, yours truly, W. G. FORSTER.

Zante, Greece, July 31st, 1878.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

We cannot undertake to return drawings or manuscripts, and must, therefore, request Correspondents to keep copies.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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Quarterly	4s. 10d.
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NOTICE TO EDITORS.

We shall be happy to exchange with the Editors of Scientific journals who receive the first numbers of THE ELECTRICIAN.

Nous serons heureux de faire l'échange avec Messieurs les Rédacteurs des Journaux scientifiques qui recevront les premiers numéros de L'ELECTRICIAN.

Es wird uns ein Vergnügen sein mit den löblichen Redactionen der deutschen und anderen continentalen Journäle und Zeitschriften, denen die ersten Nos. des ELECTRICIAN *zu Händen kommen möchten auszutauschen.*

I Signori Editori di giornali scientifici che riceveranno i primi numeri dell' ELECTRICIAN *ci faranno cosa gradita accettando il cambio che loro offriamo.*

THE ELECTRIC LIGHT.

One of the most interesting subjects to the Electrician, and scarcely less so to the public at large, is the future of the Electric Light. The history of research in this direction commences with the century. The large, and, for the time, complete work of George Adams on "Natural and Experimental Philosophy," published in 1794, makes no mention of the Electric Light; but in 1801 we find Davy experimenting with a battery of 2,000 plates, each four inches square. "He used charcoal points, made of light wood charcoal, which had been heated to redness, and immersed in a mercury bath." Since the time of Davy a good deal of attention has been directed to methods of utilising a current of electricity for general illuminating purposes. So far have we succeeded that we can even venture to light up public places and assist engineers in lighting work in progress, so that relays of men can work night and day. In Paris, indeed, a few streets have been fitted experimentally with Electric lamps. The babe has grown into a healthy youth, and promises to make a strong man.

The light of the future, what shall it be? The question is almost ripe for settlement, although in various quarters strenuous efforts are being made to calm the excitement of shareholders of gas companies. A short time ago the Paris companies reported that the Electric Light could not possibly supersede gas, and our readers will notice that the feeling of uncertainty has spread into England, and chairmen here feel it necessary to assure their shareholders that there is no danger. We are inclined to take a far different view of the case, and to say that the Electric Light is *the* light of the future, and that it will soon supersede gas, at least in open spaces. The companies with their powerful monopolies cannot stop experimental work. The public will become acquainted sooner or later with the vast difference between the Electric Light and that with which they are at present favoured. They will learn to compare the miserable system, as now existing in the first city of the world, with streets lighted as they should be in such a manner that business can proceed without inconvenience, and public opinion will then compel the introduction of the better light. One of the signs of the times is that some of the vestries are moving in the matter, and, as will be seen in another column, the Chelsea Vestry has received a report upon the subject from its surveyor, who was sent to Paris to gain information. This report is well worth attention, and conclusively shows that the Electric is the better light although it is not admitted to be the cheaper. There are one or two statements to which we should like specially to direct attention:—"The number of gas lamps provided for lighting the Avenue and Place de l'Opéra is exceptionally great, and the average distance between each light, if placed in a line, would be about five yards only." In another sentence it is admitted that in London the lamps are much farther apart than in Paris, and, therefore, the comparison between the cost of real illumination and the pretence now made is of course greatly in favour of gas. This is not a fair comparison. London is not at present lighted. When the shops are closed the lamps are just able to make darkness visible, and in some of the less important streets you might just as well be in a country village, receiving simply the light of nature, for all the good the lamps do to illumine the pavement. For the time being, without entering deeply into the subject ourselves, we would ask readers to compare the statements of Mr. Sugg, made to the Gas-Light and Coke Company, with those of Mr. Stayton, made to the Chelsea Vestry. The latter says:—"The light is vastly superior to gas, and is not injurious; there is an absence of noxious smells, both in the production and combustion; and heat in a room, so often unbearable in the case of gas, is scarcely felt; the most delicate colours are preserved; air is not consumed as in the case of gas; there is no chance whatever of explosion, and, although the light is so powerful in the streets, no accidents to horses have occurred." The former says:—"It was noticeable that during the illuminations at the national *fête*, a short time back, the oil lights and the gas jets completely overpowered the Electric Light by the volume of light given. The Electric Light looked bluish white, and the oil and gas were yellowish, but the Electric Lights were considerably inferior in volume of light given." We have been informed by fairly reliable persons that this yellowish tinge of oil and gas light is very injurious to the eyes, and that spectacles of a neutral tint are used to obviate the ill effects of the yellow glare. Mr. Sugg, in another place, says:—"These gaslights give nearly the white pure light of daylight with scarcely any actinism. The Electric Light, on the contrary, is overcharged with actinism as compared with daylight, is blue in colour, and injures the eyes." We had previously supposed that the nearest approach to sun light was the Electric Light, and we have never heard it given as a fault that the sun at midday injured the eyes of any one who was foolish enough to take a deliberate look at it. The sun is not to be looked at—neither is the Electric Light—both should be used, not abused. Mr. Sugg, however, is quite correct when he says there can be no real comparison between the cost of gas as generally used in street-lighting and the Electric Light. Still, we may venture to point out that the evidence of those who have been closely connected with the Electric Light is in

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its favour. We cannot hope to reconcile the statements in these reports with those given in the paper of Dr. Higgs and Mr. Brittle, read before the Institution of Civil Engineers last January, and discussed by members during portions of three evening meetings. These authors speak of the economy of Electric Lighting, excepting "where numerous light centres of small intensity are required, or where the space is much subdivided." When, however, the Electric Light is capable of minute subdivision it will undoubtedly compete with gas in terms of the highest advantage, since the cost of establishing a gas works is many times in excess of that necessary to supply the Electric Light to a district.

Suppose we admit that science at present is incapable of subdividing the Electric Light to any great extent, is that any reason why we should believe that science is to remain for ever powerless? She is nothing if not progressive, and what is deemed impossible to-day is laughed at as simple to-morrow. We shall hardly be accused of breach of confidence if we hint that we know more than one inventor who claims to have far surpassed what his predecessors have done in the direction of Electric lamps; and we have every reason to believe that, before these lines can reach the public eye, a new lamp, said to be almost perfect, will have undergone an exhaustive trial. We have arrived at that point where the requirements are clearly defined and the difficulties well known, and it will be a strange exception in the history of scientific progress if, with such a case in hand, we find ourselves at a standstill because Nature refuses any longer to answer inquiries.

SCHWENDLER'S TANGENT GALVANOMETER,

A SIMPLE AND PRACTICAL INSTRUMENT FOR QUANTITATIVE ELECTRICAL MEASUREMENTS.

(Compiled by O. Henneberg, M.S.T.E., from Schwendler's 'Testing Instructions.')

[CONCLUDED FROM PAGE 152.]

If we have no element of the required low resistance, we should form a compound cell, which has this resistance, by connecting up parallel a number of cells of higher resistances; when we will remember that two cells of the resistances f and f', when joined parallel, have a resistance $f'' = \frac{ff'}{f+f'}$, and three cells of the resistances f, f' and f'' respectively have a resistance

$$f''' = \frac{f \cdot f' \cdot f''}{ff' + ff'' + f'f''}.$$

Should it be required to connect up a larger number of say n cells, which have approximately the same resistance each, and are tested to have a total resistance, F, when connected up in series, then the resistance, f, of a single compound cell formed of these n cells may be calculated by the formula $f = \frac{F}{n^2}$.

Hence in our example given above we should join up parallel either two cells of about 13 units resistance each, or three of about 19·5 each. Supposing two cells of 12 and 15 ohms being at hand, then $\frac{12 \times 15}{12 + 15} = 6 \cdot 6$ ohms, or three cells of 18, 20, and 21 units resistance each, joined parallel, would give $\frac{18 \times 20 \times 21}{(18 \times 20) + (18 \times 21) + (20 \times 21)} = 6 \cdot 5$ ohms, and either of these two batteries may be used.

If the resistance to be measured exceeds very much the highest resistance that can be connected with the thin coil, the following has to take place. Increase the battery power while the unknown resistance is in circuit until a minimum deflection, which we may safely fix at 12°, is obtained. If, then, the deflection which this battery power gives through the 2000 ohms becomes too large (larger than 70°), it is better to reduce the E.M.F. in the second reading, and assume that the electromotive forces are proportional to the number of cells used in each case.

Example.—An unknown resistance gives a deflection of 15° with 200 cells while the reading through the 2000 with the same becomes 80°. Then, halving the battery in the second case, we have

$$\overset{+\;-}{a = 15{-}15} \text{ through } x \text{ with } E = 200 \text{ and } f = 3000.$$

$$a_{\prime} = 58{-}58 \text{ through } 2000 \text{ with } E_{\prime} = 100 \text{ and } f_{\prime} = 1600.$$

$$\text{Then } \frac{\tan. 15^\circ}{\tan. 58^\circ} = \frac{0 \cdot 2679}{1 \cdot 600} = \frac{200}{100} \times \frac{100 + 3000 + 2000}{100 + 1600 + x}.$$

$$\therefore \; x = 59194 \text{ ohms.}$$

II. *Comparing Electromotive Forces.*

By the general formula I. we have $\frac{E}{E_{\prime}} = \frac{\tan. a}{\tan. a_{\prime}} \frac{f + g + w}{f' + g + w_{\prime}}$.

Hence, for expressing an unknown electromotive force E in terms of a standard cell $E_{\prime}$ we have

$$E = \frac{\tan. a}{\tan. a_{\prime}} \frac{f + g + w}{f' + g + w_{\prime}} E_{\prime}.$$

For comparing electromotive forces it is advisable to take the readings through as large a resistance as possible, to avoid the influence which any fault in the determination of f may have upon the result. Hence the readings should be taken through the thin coil.

Example.—Required the electromotive force of a battery of 20 cells, having a resistance $f = 380$ (when connected up in series), in terms of the standard cell having a resistance $f' = 16$. Then, taking readings with the thin coil,

$a = +69 \; -70$, mean 69·5 with 20 cells and 2000 ohms.

$a_{\prime} = +70 \; -70$, mean 70·0 with standard cell in circuit only.

$$\text{Then } E = \frac{\tan. a}{\tan. a_{\prime}} = \frac{2 \cdot 675}{2 \cdot 747} \times \frac{100 + 2000 + 380}{100 + 16} E_{\prime}, \text{ or}$$

$$E = 20 \cdot 9 \, E_{\prime}.$$

III. *The Reduction Coefficient n.*

We have hitherto always supposed that any two readings in the same test have been obtained with one and the same coil of the galvanometer. It may, however, be necessary to take one reading with the thick coil and the other one with the thin one. Hence we must know the value of readings obtained with one coil in terms of the other. We have found before, for two currents, C and C_1, in two different coils,

$$k \, C = H \tan. a, \text{ and } k_{\prime} \, C_{\prime} = H \tan. a_{\prime}.$$

$$\therefore \; \frac{k}{k_{\prime}} = n = \frac{C_{\prime} \tan. a}{C \tan. a_{\prime}}, \text{ or}$$

$$\text{V.} \quad C = \frac{C_{\prime} \tan. a}{n \tan. a_{\prime}} \text{ where } n \text{ is an absolute number,}$$

constant for the same instrument, and may be called "the reduction coefficient."

Suppose a current, C, equal to x Webers, producing a deflection of $a = 57°$ with the *thick* coil, while a current, $C_{\prime}$, 0·006 Webers, gives, with the *thin* coil, a deflection a, 54·75°. The reduction coefficient of this particular instrument being $n = 0 \cdot 0788$, we have, by formula V., $C = \frac{0 \cdot 006 \times 1 \cdot 540}{0 \cdot 0788 \times 1 \cdot 415} = 0 \cdot 083$ Webers.

A case where it might be necessary to take the two readings through the two coils would be, for instance, the measurement of the resistance between two earth-plates. Such a resistance may be often very small, and the difference of potential between the two earth-plates may be sufficient to cause a sensible deflection of the needle through either coil when no external resistance is in circuit. Taking, therefore, readings through both the coils with the resistance x of the earth-plates in circuit only, we have

$$\frac{\tan. a}{\tan. a_{\prime}} = n \frac{g' + x}{g + x}.$$

$$\text{VI.} \quad x = \frac{n g' - \frac{\tan. a}{\tan. a_{\prime}} g}{\frac{\tan. a}{\tan. a_{\prime}} - n}.$$

Example.—A copper earth-plate buried in damp ground and a coil of iron wire sunk into a well give sufficient deflection:—

$\overset{+\;-}{a = 37{-}37}$ through the *thick* coil

$a_{\prime} = 10{-}10$ through the *thin* coil $\quad n = 0 \cdot 0788$, we have

$$x = \frac{0 \cdot 0788 \times 100 - 1 \times \frac{0 \cdot 7536}{0 \cdot 1763}}{\frac{0 \cdot 7536}{0 \cdot 1763} - 0 \cdot 0788} \text{ whence } x = 0 \cdot 36 \text{ ohm.}$$

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Now, a standard cell of E.M.F. $E_{,}$ and internal resistance 20 gives, with the same instrument, through the thin coil,

$a_{,,} = \overset{+}{72} - \overset{-}{72}$, from which we deduce the E.M.F. of the earth-plates = E by formula IV.

$$E = \frac{0{\cdot}1763}{3{\cdot}078} \times \frac{0{\cdot}86 + 100}{100 + 20} E_{,,} \text{ whence } E = 0{\cdot}048\, E'.$$

V. *Determination of the Ratio between the Resistances of both Galvanometer Coils and the Ratio between the Resistance of one Galvanometer Coil and one of its corresponding comparison Coils.*

Select two cells which give the same deflection through the thick coil g with no external resistance in circuit. The internal resistance of these cells must then be equal, say $= x$. Take two readings, one, a, with one cell only, and the other one, $a_{,,}$ with both cells connected up parallel, as compound cell, then we have

$$\tan. a = k \frac{E}{g + x} \text{ and } \tan. a_{,} = k \frac{E}{g + \frac{x}{2}}$$

$\therefore \frac{\tan. a}{\tan. a_{,}} = \frac{g + \frac{x}{2}}{g + x}$, putting $2\frac{\tan. a}{\tan. a_{,}} = m$, dividing by g and developing $\frac{x}{g}$, we get $\frac{x}{g} = \frac{2 - m}{m - 1} = y$.

Next take a reading, $a_{,,,}$ with the same cell (resistance x), without any external resistance in circuit, through the thin coil $g_{,,}$

$$\tan. a = k \frac{E}{g + x},\ \tan. a_{,,} = k_{,} \frac{E}{g_{,} + x}.$$

$\therefore \frac{\tan. a}{\tan. a_{,,}} = \frac{k}{k_{,}} \frac{g' + x}{g + x}$, say $= y$. Divide by g, put $\frac{k}{k_{,}} = n$, and for $\frac{x}{g} = y$, its value, when we get,

$$\frac{g'}{g} = \frac{1}{n\,(m - 1)} \left\{ y - n\,(2 - m) \right\} = s.$$

n is known, m and y are found by experiment, and, therefore, s — the ratio of the galvanometer coils can be calculated. If the calculated value agrees with the one taken from the memo., we may assume with certainty that the absolute magnitudes of the resistances of the galvanometer coils have not altered.

To ascertain the ratio between the resistances of one galvanometer coil and one of its corresponding comparison resistances, take two readings, with the same battery and through the same coil, one, a, without any external resistance, and the other one, $a_{,,}$ with the resistance coil to be controlled in circuit. Then we have, with the thick coil, for instance,

$$\tan. a = k \frac{E}{g + x} \text{ with no external resistance,}$$

$$\tan. a_{,} = k \frac{E}{g + x + w} \text{ with } w \text{ in circuit.}$$

$\therefore \frac{\tan. a}{\tan. a_{,}} = \frac{g + x + w}{g + x} = m'$. Divide by g, substitute for $\frac{x}{g} = y$ its value, and develop $\frac{w}{g} = z$, when we get $z_{,} = \frac{m' - 1}{m - 1}$.

Now, again, if this proportion $z_{,}$ corresponds with the one that can be calculated from the values in the memo., we may rest assured that no perceptible alteration of the resistances has taken place.

It is scarcely necessary to mention that the instrument can also be used as a battery detector and as a signalling instrument. In the latter case, the thin coil is to be connected with the line, and if the aluminium pointer is well adjusted within the two copper stops which limit its play, signals can be read which are due to a current = 0·002 Webers.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the very readable mathematical paper on Schwendler's Tangent Galvanometer there is one expression, occurring p. 152, first column, in your last issue, which is unintelligible, at least to ordinary students, viz.: "Putting $\frac{E = E' = E}{f = f' = f}$ in Form I."

Is there not some mistake here?—Your attentive reader,

RELAY MAGNET.

ANSWER.

Putting $E = E' = E$ and $f = f' = f$ in Formula I. means not only that the quantities referred to are to be taken as *equal*, but that they are to go, in their new relations, under the names E and f respectively.

THE BRITISH ASSOCIATION.

SECTION G.—MECHANICAL SCIENCE.

Mr. EASTON, C.E., in the chair.

Mr. W. H. PREECE, C.E., read the following paper on "Recent Advances in Telegraphy."

The overpowering sensation produced by the telephone and other acoustic instruments that have followed in its wake has led many people to imagine that improvement in telegraphy has ceased, at least in this country. It has been publicly stated by very high authorities that, since the transfer of the telegraphs to the State, invention in that art has left the shores of the United Kingdom and flown to those of America. Moreover, it has been intimated that the monopoly in telegraphy possessed by the State has checked improvement.

Such statements are made in ignorance of the facts. Greater improvements have been made in telegraphy during the past eight years than in any previous period of similar duration. Inventions have, it is true, found their way from America, but they have also travelled in the opposite direction, and have taken root there. Indeed, improvement in telegraphy was never more active in England than it has been since the Government has managed the business.

The object of this paper is to prove the above propositions.

In order to approach these large questions with some degree of method I will preface my remarks with a few definitions:—

I. Any combination of signals expressed—
(*a*) By words;
(*b*) By the elements of written language; or,
(*c*) By preconcerted symbols
conveying an idea,—is a *message*.

II. *Electric telegraphy* is the art of conveying such messages to places beyond the reach of the ear or the eye by means of electricity.

III. Currents of electricity can be produced by chemical action, by motion in a magnetic field, by heat, and by the conversion of other forms of energy into the electrical form. They can produce signals by means of magnetic, thermic, or chemical effects.

IV. Electric signals can appeal to the consciousness through any one of the senses, but in practice they utilise only those of *sight* and of *hearing*. Hence we have *visual* telegraphy and *acoustic* telegraphy.

V. They can be conveyed to distant places by means of conductors and insulators, which can be influenced by machinery or by human agency. Hand transmission is called *key* telegraphy, mechanical transmission is called *automatic* telegraphy, verbal telegraphy is called *telephony*.

VI. The *speed* at which messages can be sent is regulated by the number of currents required to form each signal, and by the rate at which the successive currents of electricity which determine the signal can be sent. Hence we have *ordinary* and *fast-speed* telegraphy.

VII. The capacity of the wire for the transmission of messages is also regulated by the number which can be *simultaneously* transmitted. Hence we have *multiplex* telegraphy.

Taking the improvements that have been made in telegraphs generally during recent periods, I will first of all deal with the receiving apparatus—the apparatus that translates to the mind through the eye or the ear the messages sent. The general feature of the apparatus used in Europe was eight years ago dependent on sight, while in America it was dependent on sound. In England we had (1) the needle instrument of Cooke and Wheatstone, which was and is still universally employed on our railways. The vibrations of a little needle form the elements of written language, so that messages are spelt out letter by letter; (2) the Morse recording instrument, which indicates the signals by the combination of dots and dashes, marked or embossed on paper, and which is still the most generally used instrument throughout Continental Europe; (3) the Hughes type printer, which prints its messages on strips of paper in bold Roman letters; (4) the A B C or alphabetical instrument of Wheatstone; and (5) the bell instrument of Bright, which indicates the signals by the combination of the sounds of two different-toned bells.

In America, though the type printer has been very largely used, the principal instrument for many years past has been the Sounder, which conveys dots and dashes to the mind of the operator by the varying duration of the sounds.

The gradual exercise of that law of evolution—the survival of the fittest—is in England slowly replacing the Morse recorder by the more simple sounder. It has removed the type printer excepting in connexion with cables to the Continent. It has commenced to supplant the needles, which appeal to the eye by a method which appeals to the ears, in fact, a modified form of the bell, the first sound instrument ever introduced, and its general tendency is to reduce all apparatus to one stage of uniformity. Acoustic apparatus has proved itself to be more simple, more accurate, and more expeditious than visual apparatus, but its capacity is limited to the rate at which the ear can comprehend signals. Again, the speed is limited by that at which the hand can send and write, and the operations of sending at one end and writing at the other must be simultaneous, while recorded messages can wait, or they can be distributed among several writers. Hence all apparatus fixed on fast-speed circuits must necessarily remain visual, while all other ordinary apparatus will probably be acoustic.

The principal improvements that have been recently introduced in receiving apparatus have been S. A. Varley's and Spagnoletti's induced needles, to remedy the disturbances due to atmospheric electricity; Siemens' direct ink-writer, to remedy the irksomeness to the eye of the embossed paper of Morse; Wheatstone's A B C dial instrument so much used for private purposes; Sir W. Thomson's syphon recorder, and Varley's Condenser, both of these being designed for expediting the rate of working through long submarine cables.

Bain's chemical recorder (reproduced after many years interment) for expediting the speed of automatic working through long circuits.

Neale's acoustic coil for assimilating the single needle and bell systems.

Bell's telephone, which, however, is at present employed only on a very limited scale in England.

With respect to sources of electricity. Innumerable improvements have been made in batteries, but two only need be named, which, for power, efficiency and economy, far supass all others, and are being very considerably employed in the United Kingdom, viz.:—

Leclanché's, where ammonic chloride and manganic peroxide are the

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principal exciting agents, and Fuller's where Poggendorff's potassic bichromate solution is the exciting agent.

These two batteries are gradually replacing with great economy the Daniell form hitherto so largely used.

In sources dependent upon motion in a magnetic field, such as Wild's, Siemens's, and Gramme's machines, so largely used for light and electrolytic purposes, though experiments have been made, they have not yet shown themselves equal in efficiency to batteries for telegraphic purposes.

It seems, however, very desirable that so simple a form of energy as the motion of a steam engine or a turbine should be utilised as an electric machine, since, probably, it is the most economical form by which the necessary conversion can be made. In batteries the waste of energy is enormous.

In sources dependent on the conversion of heat into electricity Clamond's thermo-electric pile, both in its original form and as modified by Leonard Wray, have been extensively experimented upon, but without any decided result. It is, however, worthy of record that for many weeks forty-three circuits were maintained in working order by one pile, in which the energy of gas jets was converted into currents of electricity.

It is, perhaps, in improvements in conductors that England has shone most. She has supplied the world with cables.

Her iron-clad ropes rest on the bottom of every sea, and her cable fleet is seen nearly everywhere. The Post Office alone possesses sixty-two cables, embracing 1,060 miles.

The broad Atlantic is spanned with six cables, two of which are, however, dead and irrecoverable. This is due to defective design, and not to any inherent difficulty in ocean telegraphy.

In the manufacture of iron wire England stands pre-eminent. Messrs. Johnson, of Manchester, have led the way with their continuous "rolling" method.

Our moist climate, smoky atmosphere, winter fogs, and salt-sprayed land have proved a sad source of trouble in insulating our wires. The inventive faculty has been directed to surmount these difficulties of our climate more than to overcome any other source of trouble. Messrs. Clark, Varley, Andrews, and many others have battled against these difficulties in vain. Several improvements are now under trial, such as Cordeaux's, to facilitate cleaning; Fuller's, to increase resistance; and Messrs. Johnson and Phillips's, who have struck out quite a new line by inserting a section of oil in the path of the current; indeed, we are always experimenting in this direction. The higher-classed apparatus that is being introduced needs higher-classed insulation. The difficulties of this country are not experienced elsewhere, and therefore our efforts to cure the evil are not appreciated. The form that is found perfect in America failed miserably in England, and those accepted on the Continent are not to be compared to those in use here when erected under similar conditions.

It is perhaps in the sending department that the greatest changes have been made.

Varley's double-current system, working with polarized relays, has survived all others; but the keys used in working it, which at first were cumbrous, and therefore slow in action, have been revolutionised by Mr. Stroh, and by the Post-office electricians. Keys manipulated by hand cannot be made to send more than forty-five words per minute, whereas the limit of recorders far exceeds this. Moreover, the hand soon tires, and cannot maintain the speed. Indeed, the average rate of sending of the best operator does not exceed thirty words a minute.

Alexander Bain, in 1843, proposed to replace hand-keying by automatic sending, and thus to attain much higher speed.

The ordinary dot and dash of the Morse alphabet was mechanically "punched" out of paper slips, and the paper thus punched automatically used to send the currents. The punched paper was mechanically drawn, at any speed, between a metal roller and a "style," which it separated, but which came into contact at every opening, and thus completed the circuit and sent the signals. But Bain was before his time. Fast speed telegraphy was not then wanted. To be practically successful, invention and necessity must exist together. The old proverb quaintly expresses the idea, "Necessity is the mother of invention," but the child is often born before its mother. This was the case with Bain. There was not business enough to fill a wire, hence the system remained in abeyance. It was taken up again by Wheatstone, in 1868, when the necessity for improved methods began to be evident. Wheatstone devised a different system of punching, based on the principle of the Jacquard loom. This system has been very extensively emyloyed by the Post Office. At the present moment there are over 170 instruments worked. Indeed, without its aid it would have been impossible to have coped with the enormous amount of news which the cheap tariff thrust on the Post Office wires. Wheatstone's apparatus has been entirely remodelled and improved by the Post Office electricians. Nothing but the original idea remains, and the machine now turned out by Mr. Stroh is one of the most perfect pieces of mechanism employed in any art.

The telephone bids fair some day to be of use in some branches of telegraphy, but its progress has been disappointingly small. Everyone has been experimenting upon it. Scores of improvements have been suggested or patented, but it seems to have sprung into existence with all its perfections and imperfections on its head.

In fact, of all the instruments that I have seen and tried, those which I brought over from America last year and exhibited before this Association in Plymouth remain the best, and surpass all rivals. It has not at present found much favour in England. Its effects are feeble. It is too sensitive for practical use on existing lines. It requires complete quietude not only in the air about it, but in the wires conveying its signals, and its employment has been checked by the outrageous terms demanded.

The changes and improvements that have been made in the sending apparatus have been accompanied by equal improvements in the speed of working in the receiving apparatus. The laws of induction on wires and in instruments, the causes of retardation in working on long lines and submarine cables, have been carefully studied by English electricians, and means have been devised to reduce or remove the deteriorating influences. The currents sent to produce signals are varied so as to roll into one another and to become indistinguishable. While on a short line it is possible to attain 1,000 words a minute or more, the rate of working rapidly diminishes with distance, and between London and Dublin it was difficult to maintain more than seventy words a minute. Modes of compensating upon the line itself the currents sent by the Wheatstone transmitter, and of connecting up the coils so as to eliminate the effects of currents induced in them have been successfully introduced by the Post Office electricians, so as to increase the rate of working on long lines very considerably; and very recently relays of exquisite manufacture have been constructed which, inserted as translating relays or repeaters at intermediate points, have still further increased the rate of working on automatic circuits between London and Dublin fifty per cent. Indeed, while the question of increased telegraphic communication between Ireland and England was under consideration, this more rapid mode of working solved the question. It has in some instances increased the rate of working 100 per cent.

Bain's original chemical recorder has been resuscitated, but its use is attended with disadvantages which have not led to its extended employment. It is in use in Dublin.

Bain's recorder has also been resuscitated in America. Mr. Little applied to it a condenser as a shunt to prevent the confusion or running together of signals, due to induction on the line when running at high speed. He called it "an overflow dam." Mr. Edison effected the same thing in a better way by using an adjustable electro-magnet as a shunt. Immense speed was attained by this means.

It will thus be seen that the distinguishing feature that has characterised the improvements made by the Post Office officials has been in the direction of fast-speed telegraphy; and it is not too much to say that they have more than quadrupled the working speed of wires.

The improvements made towards increasing the capacity of wires is wonderful. Where one message only is sent on one wire, in one direction, it is called *simplex* telegraphy.

Gintl in 1853 showed how it was possible to send two messages, in *opposite* directions, on the same wire at the same time, and, therefore, rendered possible *duplex* telegraphy. He balanced the currents passing through the home station, so that equilibrium was only disturbed when the sending station was working at the same time, and then the disturbance exactly coincided in amount with the current which would have arrived to indicate the signals from the distant station. So that whether the home station were working or not, its apparatus continued to indicate the signals received from the distant station. Gintl's plan was considerably modified in 1854 by Siemens, Frischen, Edlund, and others, but for nearly eighteen years it remained a scientific novelty, principally because the invention was before the necessity. It was not wanted in 1855. But it was also deficient in one respect. Mr. J. B. Stearns, in America, removed this defect in 1872 by applying a condenser to compensate for the effects of induction on the line, which were not understood in Gintl's day, and duplex telegraphy became a practical system.

There are now in England nearly 200 circuits so worked, and our ocean cables, by the aid of peculiar condensers, introduced by Muirhead and Taylor, are gradually being duplexed.

Bernstein, Stark, Siemens, Kramer, and Bosscha, in 1855, showed how two messages could be sent in the *same* direction at the same time, on the same wire, and hence rendered possible *diplex* telegraphy.

The principle of this system of working consists in having two apparatus, the one worked by weak currents and the other worked by strong currents, and so arranged that they work independently of each other; but the plan has never been brought into actual practical use as a duplex system. When, however, these two plans were combined together, they formed *quadruplex* telegraphy.

This combination was suggested by Bosscha and Stark, in 1855, and by Mr. Oliver Heaviside, in 1873. It was devised by Mr. Walby, a Post Office official in Dublin, also in 1878. It was patented in this country by Mr. Stearns, in 1874. It was, however, for the first time put into practical operation by Messrs. Edison and Gerritt Smith, in 1876, upon the lines of the Western Union Telegraph Company, in America, where it is now applied to sixty circuits. It is now being introduced by the Post Office.

Its method consists in working one apparatus with reverse currents, independent of their strength, and the other apparatus with strong currents independent of their direction, both being duplexed. Hence it is in fact a double duplex system. It works perfectly on short lines, but it becomes troublesome on long lengths.

It is capable of considerable extension and variation. In America it works to distances exceeding 1,000 miles by means of relays or repeaters fixed about the centre of the circuit. Thus New York works to St. Louis with relays in at Pittsburg. At the present time West Hartlepool and Middlesbrough are each working duplex to London—on separate wires to Leeds, but on the same wire to London.

Telephone currents are very minute currents following each other with great rapidity, and they can be superposed on ordinary working currents without interfering with their action on ordinary telegraphic apparatus. Mr. Cromwell Varley utilised this principle in 1870, by patenting what we may call *harmonic* telegraphy, but it remained for Mr. Elisha Gray of Chicago to work the system out practically. He utilises the wires employed for serving "way" or intermediate stations by working them also harmonically between their terminal points, thus vastly increasing their capacity. This system is now under trial in America, and it is exhibited in the Paris Exhibition, where Mr. Gray is also showing an *octoplex* system, or a mode of sending eight messages on the same wire at the same time, which is said to have been experimentally tried with success between New York and Philadelphia.

Other systems for increasing the capacity of wires have also been devised on the Continent. Thus Meyer (whose instrument was exhibited at the Vienna Exhibition of 1873, and is now in use on a small scale in France and Austria) sends four messages in the same direction apparently at the same time; but they are not sent simultaneously, the signals are divided and distributed so as to obtain the maximum carrying capacity of the wire, and therefore the practical gain is not great.

M. Baudot, whose apparatus is exhibited at the Paris Exhibition, sends five messages upon the Hughes apparatus in the same direction, but they also are not simultaneous, and though by utilising the intervals of time occupied by the type wheel in revolving and distributing the signals, he increases the capacity of the wire, the gain is not very evident. The instrument is very complicated, and its practical success questionable.

The French Government is also trying an automatic system of type printing, devised by M. Olsen, which is said to increase the capacity of the Hughes type printer 33 per cent.

Now, of all these systems, the most valuable, successful, and practical are the Wheatstone Automatic and the Quadruplex. The average speed attained

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on the Automatic, on an average circuit worked simplex, is 100 words per minute, which becomes 200 words per minute when worked duplex. The average speed attained on the Quadruplex is 120 words per minute. Hence, when duplexed, Automatic is more capacious than the Quadruplex, but the elasticity of the Quadruplex makes it a valuable help to the Automatic system, and when the two are combined (which has recently been done by the electricians of the Post Office) the advantages of both are secured. One side of the quadruplex is worked automatically and the other side by ordinary keying.

But it must be remembered that each system has its disadvantages—principally the employment of a more highly trained staff. The Automatic system involves previous preparation, and therefore preliminary delay. The complication and delicacy of both systems involve better-maintained lines, and their failure tends to much greater trouble. It is not advisable to trust all one's eggs to one basket. There is a distance within which each becomes disadvantageous and expensive, and where it is cheaper and better to erect extra wires.

Now, these systems of fast-speed and multiplex telegraphy have grown up in England under the fostering care of the Post Office since the transfer of the telegraphs to the State, and therefore I contend that I am justified in saying that greater improvements have been made in telegraphy during the past eight years than in any previous period of similar duration.

Necessity drove the Americans to the introduction of quadruplex telegraphy, as it drove us to the employment of the automatic system. The increased business demanded increased capacity of wires. Automatic telegraphy in America was in the hands of opponents. All the skill of the Western Union Telegraph Company was devoted to the improvement of multiplex telegraphy, and the quadruplex is the result. Neither duplex nor quadruplex telegraphy were, however, invented in America. They were imported there, but in a very crude condition. The great practical skill and ingenuity of our cousins made them what they are—the most valuable adjuncts to telegraphy.

It will be observed that in the above enumeration England stands prominent as the home of the inventor. While she can boast of Wheatstone, Cooke, Bain, Thomson, Clark, Varley, Fuller, &c., and Europe can boast of Gintl, Siemens, Frischen, Meyer, &c., America has her Morse, Hughes, Stearns, Edison, and Gray.

In 1868 the Western Union Telegraph Company, feeling that their telegraphic system was not up to the requirements of the age, secured the valuable services of Mr. Cromwell Varley, who educated them up to the European standard of electrical knowledge, and they have certainly bettered their instruction.

America has freely adopted our system of pneumatic telegraphy. They have introduced our methods of testing. They have adopted Johnson's method of manufacturing iron wire. They have introduced on some lines automatic telegraphy, modified by Messrs. Little and Edison. They are trying our superior batteries.

Hence, while we have not been slow to avail ourselves of their advances, they have equally availed themselves of our progress.

Telegraphy is thus cosmopolitan. Whatever of value and advance is produced in one nation is adopted by all. Invention has not left the shores of England. The English Telegraph Department stands in the front rank. Foreign Governments freely avail themselves of our experience. Our models, our plans, and our manufactures are found in every clime.

It remains for me to say a few words as to the part played by the Post Office in fostering these advances. The system of news wires is unique in its kind. Forty-seven news circuits and twenty-two special wires are made up every day for the transmission of intelligence. News is transmitted direct from London to every town at which a daily paper is published. There is thus scarcely a town in the United Kingdom where every man has not on his breakfast table a morning paper containing the debates of Parliament of the previous night.

This is maintained by the automatic system. Half a million words are frequently sent in one night from London alone. When Lord Beaconsfield gave his address in the House of Lords on the results of the Berlin Congress, 526,250 words were transmitted from T.S. the central station.

There is not a branch of the service that has not been improved. New batteries, new insulators, preserved poles, improved wires, the most perfect relays, and multiplex apparatus have all found their way into the Post Office service. In 1873 15,535,780 messages were transmitted over 105,285 miles of wire, being an average of 147 messages per mile of wire, while in 1878 22,171,783 were sent over 113,333 miles of wire, being an average of 200 messages per mile of wire. Of the 8,000 miles of additional wire which have been put up more than one-half is for *private* wire purposes; therefore the message average is really even higher than that given. Indeed, only 4,000 miles of wire have been erected to transmit nearly 7,000,000 messages, or an increase of nearly 50 per cent. of work.

No one has ever been heard to complain of the action of the Post Office in adopting improvements but, perhaps, some disappointed inventor. It must be remembered that improvement is invariably the result of inventive power combined with practical experience well tempered with theoretical knowledge. Practical inventions rarely emanate from without. The long list that I have enumerated is, without exception, composed of men who have possessed these qualifications; but the great majority of patents are taken out by those who do not possess them at all. They are the most troublesome men to deal with. They cannot be convinced of their errors, and their want of experience prevents them from seeing their failure; but of the numerous patents that are annually taken out, how many complaints are made by those who have not been fairly and properly treated? The table below gives a list of patents which have been taken out for improvements in telegraphy for each year since 1862.

They are thus now as numerous as ever; indeed, the average of the last eight years exceeds that of the previous eight; hence, I am justified in saying that the possession of the telegraphs by the State has not checked improvement. Moreover, the telegraph system outside that of the Government is as great now as the whole telegraph system of the country was before the transfer, and inventors, if they are dissatisfied with the Government, have the numerous cable companies and the great railway systems of this country to fall back upon. Private enterprise is not dead.

The fact remains that telegraphy, whether for commercial or railway purposes, is more highly developed in England than in any other country, not excepting America, and this development is due as much to the action of the State in purchasing and managing the commercial system of the country as to the competition that remains between nation and nation and between company and company. The lines of the Post Office are now worked with a view to a fair commercial profit as much as any private concern. The action of the Government in all departments is jealously watched by its master, the public. This master is not always just, nor generous. Its prerogative is to find fault with the Government in all that it does, and it is well that this right be exercised, for it forms a very valuable check on abuse, it strengthens discipline, and it secures a worthy discharge of duty.

I can speak from the experience of a commercial and of a Govermental department extending over twenty-five years, and I have no hesitation whatever in asserting that there is as much zeal, energy, and enterprise in the one as there is in the other. The control of Parliament and of the Press exercises a far more disciplinary and supervising power on the management of a Government department than any half yearly meeting of shareholders or occasional committee of investigation.

IMPROVEMENTS IN TELEGRAPHY.

YEAR.	1	2	3	4	TOTAL.
1862	29	9	7	6	51
1863	13	7	8	3	31
1864	24	3	3	3	33
1865	24	27	8	7	66
1866	25	13	7	9	54
1867	39	7	4	4	54
1868	31	5	6	7	49
1869	28	11	3	6	48 average —48½
1870	26	5	4	4	39
1871	17	3	4	10	34
1872	50	5	3	4	62
1873	49	5	2	6	62
1874	50	13	2	2	67
1875	25	12	2	2	41
1876	35	25	3	3	66
1877	42	3	—	1	46 average —52½

NOTE.—Column 1 contains the number of patents which refer exclusively to land lines.

Column 2 those which refer exclusively to submarine work.

Column 3 gives the patents which refer to the manufacture of telegraph material.

Column 4 gives those patents which bear partially upon telegraphy. and partly on other arrangements to which such inventions are also applicable.

REPORT ON THE ELECTRIC LIGHT.

BY MR. G. H. STAYTON, C.E.

TO THE VESTRY OF THE PARISH OF CHELSEA.

GENTLEMEN: In accordance with your instructions I have considered the question of the electric light in lieu of gas for street lighting, and have visited Paris to inspect the system now in operation in that city, with a view to reporting fully thereon.

I had interviews with M. Alphand, Director of Public Works (City Engineer); M. Jabloschkoff, the inventor of the Electric Candle; M. Guichard, C.E., Agent to the General Electricity Company, and others, all of whom most readily afforded me valuable information upon the subject.

I learn that the Municipality of Paris have contracted with the above Company to light certain streets and places, notably the Avenue de l'Opéra and the Place de l'Opéra, which form a magnificent new street nearly 900 yards in length and 30 yards wide. To effect this the Company have erected 46 lamp columns for the electric lights, at an average distance of 38 yards apart on each side of the street, and have established three electric stations.

The lights consist of the "Jabloschkoff Candle," utilised by means of the "Gramme" Dynamo-Electric Machine, by the aid of which 16 candles (*i.e.* lamps) are maintained, a steam engine being required to set and keep it in motion.

An electric machine is provided for every 16 lamps, the engine being placed in one instance in the front basement of an unfinished building, in another in a back room on the ground floor of similar premises, and in a third in the basement of the Opera House.

The electric apparatus is worked by a 16 h.p. steam engine with shaft and belts (1 h.p. per lamp being thus absorbed), from which conducting wires for the current are laid in drain pipes under the footways, and carried to the lamps.

Upon a stand fixed on the top of the lamp posts at a height of about 16 feet, opaque globes (Verre Opale) about 18 inches diameter are fixed, and they contain what is called the "Chandelier" which receive the candles.

An electric candle costs 7½d. and burns one hour and a half, but the chandeliers are made to receive in advance any given number of candles, and by means of a simple self-acting arrangement when a candle is nearly consumed, the current is passed to a new candle, and the continuance of the light is assured without any visible interruption.

The intensity of a single electric light is stated to be equal to 700 wax candles, but the globes take off about one-third of the light. An ordinary street gas-light in London being equal to twelve or fifteen candles, the superiority of the electric light may be easily understood.

The contract referred to may be termed an experimental one to a certain extent. The company undertook to light the lamps for a period of six months, ending in November next, from dusk till shortly after midnight, and to provide the whole of the apparatus for 1f. 45c. (1*s.* 2½*d.*) per light per hour. Shortly before the electric light is extinguished about one-third of the gas lamps are lighted and continued till sunrise, the former light being unnecessarily powerful and too expensive to be maintained all night.

The number of lamps provided for lighting the Avenue and Place de

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l'Opéra by gas is exceptionally great; I should estimate that there are no less than 400 lights. The columns are placed at very short intervals, and have either three or five lamps thereon, consequently the average distance between each light if placed in a line, would be about five yards only.

Although such ample provision is made for gas, the City Engineer says "that the cost of the Electric Light is four times that of gas, but a greater amount of light is obtained." On the other hand, in the lighting of the courtyard of the Hotel du Louvre, it is asserted that a saving of 29 2-3 per per cent. is effected by replacing 201 gas lamps by 16 electric lights, although 3½ times the amount of light is given.

It is scarcely necessary to remark that the leading thoroughfares in Paris are exceedingly well lighted. There are altogether 39,000 lamps in the city, the annual cost per lamp being 5*l.* 16*s.* Gas is supplied to the Municipality at *one-half* the price charged to private consumers.

The electric light has also been adopted for lighting the Place du Théâtre Française, the Madeleine, the Arc de Triomphe, the Orangerie des Tuilleries, the Magasins du Louvre, and about thirteen other places in Paris. It is also in operation in the principal places in Brussels, Madrid, and St. Petersburg.

Cost of Adoption.—The distance between the lamps in Chelsea being much greater than in Paris, and there being only one lamp upon each column, greatly increases the comparative cost of the systems. They are somewhat irregularly placed, but the distance apart on each side averages about:—55 yards in Sloane-street, 70 yards in King's-road, 35 yards in Lowndes-square, 35 yards in Cadogan-place, 28 yards on the Chelsea Embankment. In Piccadilly the distance is 30 yards, and in Cromwell-road, South Kensington, 27 yards.

To adopt the electric light for Sloane-street, which is 1,100 yards long and 20 yards wide, would necessitate two electric stations, each of which would require a 16-h.p. steam engine, including shafts, belts, &c., a "Gramme" dynamo-electric machine, a shelter or other building for the machinery and apparatus, the alteration of 16 lamp columns, together with globes, stands, connectors, and the necessary conducting wires, the total expense of which would amount to the sum of 3,200*l.*

The cost of lighting 32 electric candles, including coal, oil, waste, wages, &c., *per hour* would be 16*s.*, and 3,250 hours consumption per annum would be required unless the lights were extinguished and gas substituted at midnight, as in Paris, in which case the annual cost would not be so great.

The present cost of a gas lamp in Chelsea burning 3,850 hours per annum is 3*l* 6*s.* 7*d.*, therefore the expense of the 40 lamps in Sloane-street is 8½*d.* per hour.

To light the Chelsea Embankment which is about 1,530 yards long, and has 109 gas lamps (including those on the River Wall belonging to the Metropolitan Board of Works), would require a first outlay of £4,800 for 48 lights of 3,250 hours per annum, with an hourly cost of 1*l.* 4*s.* The present cost of the gas lamps is 2s. 1½d. per hour for 3,850 hours per annum.

To adopt the system in Sloane-square (where there are but 17 lamps) would scarcely be practicable, even if the motive power could be obtained from the pumping engine of the Metropolitan District Railway Station, or from the engine of any manufactory in the locality after the close of the ordinary day's work.

In connection with the foregoing estimates, it must be remembered that in the case of Sloane-street, the amount of light would be 31 times greater than at present, which might be considered an unnecessary expenditure; but the electric current is said to lose 40 per cent. of power beyond a radius of about 250 yards, consequently a "Station" for 16 lights has to be established at about every 500 yards which greatly increases the expense. Probably half the above number of electric lights would be found sufficient for effectually lighting Sloane-street, if the quality of the current could be fully maintained at double the distance, by which means alone the cost would be reduced 50 per cent.

General Conclusions.—I have arrived at the following conclusions, which may be thus stated briefly, viz.:—That the present arrangements for electric lighting are unsuitable for long distances (in this I am supported by the City Engineer of Paris), especially in London, where the lamps are so much farther apart than in Paris. The close proximity of the electric stations is a great drawback to the system, and their establishment in business streets would be a matter of considerable difficulty. These are the disadvantages of the system. The following are the advantages:—

About 1½ hours' daily consumption is saved in consequence of instantaneous lighting and extinguishing; the light is vastly superior to gas, and is not injurious; there is an absence of noxious smells both in the production and combustion; the heat in a room, so often unbearable in the case of gas, is scarcely felt; the most delicate colours are preserved; air is not consumed as in the case of gas; there is no chance whatever of explosion, and, although the light is so powerful in the streets no accidents to horses have occurred.

If the cost of producing the "Gramme" machine (10,000f.) could be reduced or a less expensive one be adopted; if hydraulic, or some other less expensive power, such as a petroleum engine, could be utilised as the motor in lieu of steam, or even a smaller amount of power than one-horse per lamp be rendered sufficient; if the distance between the electric stations could be greatly increased, the arrangements made capable of minute subdivision, and by some simple method the current could be branched off for household or other requirements, I feel sure that the public would gladly welcome such a change, and it would compete with gas under highly advantageous conditions.

The question is now largely occupying the attention of scientific men. At a recent meeting of the Institution of Civil Engineers, its discussion occupied three evenings. One speaker asserted "that one of the greatest advantages he saw in its introduction, was the possibility of its adding to the hygienic properties of buildings as fresh air could be preserved, because the electric light consumes none, whereas gas consumes an enormous quantity." Another speaker (Sir William Thomson) having made a suggestion as to the construction of a copper tube for producing the electric light at a great distance, said "that he believed it would be possible to carry the electric energy to a distance of several hundred miles. The theory appeared to be that towns henceforth would be lighted by coal burned at the pit's mouth, for which purpose the dross could be used." On the other hand, another speaker asserted "that in all probability, *before* the electric light was perfected, the cost of manufacture of gas would have been so far reduced as to lift it even further beyond the reach of competition, and that gas-makers' future promises in regard to improvements were as bright as those of the promoters of the electric light."

After a careful consideration of the whole question, I am of opinion that at present the electric light is *not* suitable for street lighting in the metropolis; that it *is* suitable and can be utilised with splendid effect in large squares and places, such as Trafalgar-square or Parliament-square; but although in each of these places at the present time the lamps are numerous, the cost would be greater than gas.

I am also of opinion that so soon as the modifications alluded to can be effected (particularly as to the electric current being carried to a much greater distance, thereby reducing the cost), the electric light will very soon supersede gas to a considerable extent, the attendant advantages being so great.

THE ELECTRIC LIGHT.

At the recent general meeting of the Gaslight and Coke Company, held at their chief office in Horseferry-road, Westminster, the Governor, the Hon. Richard Howe Browne, in the course of his address in moving the adoption of the directors' report, said:—I now come to a point which many of you, I have no doubt, have anticipated that I should mention; but, as it has attracted a great deal of attention out of doors, I think you are entitled to possess the same amount of information as the board possesses as to the probability or the possibility of the electric light superseding the present mode of illumination by gas. It has been the duty of this board—and I will say they have left no stone unturned—to endeavour to come to the truth, and to form a just conclusion as to the merits of this new mode of illumination. We have directed our attention on various occasions to it—we have given it even in this room a fair trial, and it is the opinion of the board, and it is my own firm conviction, that proprietors of gas companies have not the slightest reason to appprehend any diminution in their profits by the introduction of the electric light. I made some remarks on this subject from this place at the last meeting, and at the meeting before, which remarks were most freely commented on, and in a most friendly manner, by the Press, and I think it is unnecessary for me to say that nothing has occurred since I made those remarks to alter my opinion as to the possibility of applying the electric light. We are quite aware that in large public spaces the electric light, though a disagreeable one, may be applied, but there has not been, I believe, a single instance of it being introduced as a mode of lighting houses, nor indeed in the lighting of public lamps in this country. Therefore we have to see if they will venture on such an experiment; but, as far as my own judgment goes, if they do they will thoroughly fail. The directors have had a most able report made to them by a gentleman of very great scientific acquirements—a gentleman fully capable of forming a just judgment upon the whole question, and I will read to you presently one or two paragraphs from his report. I am alluding to a gentleman who is very well known to almost every gas proprietor in the kingdom, Mr. Sugg. He proceeded to Paris as an exhibitor of gas apparatus, and employed a great deal of his time in investigating the process of electricity as applied to illumination, and the conclusions he has come to are embodied in a report. At the commencement of this report—which is too long to read to you—he confesses that very great strides have been made in improving the light, but he says that the expense of the light is in darkness at present. When I went to Paris last Christmas to see the manufacture from the beginning of the electric light, I made exactly the same remark that Mr. Sugg has made. I totally failed at getting anything like the expense of the light as compared with the expense of gas lighting; and, as to the unsteadiness of the light, I pointed it out to the person most interested in it, and he was obliged to confess that there was a certain variation in its volume of light. Mr. Sugg says in his report:—"I have carefully noted the effects of the electric lighting on a large scale as shown in Paris, in the Avenue de l'Opéra, in which there are a great number of powerful lights in close proximity. Although, undoubtedly, the place is well lighted, yet it does not convey to my mind anything like the effect which ought to be produced from the enormous number of candles it is supposed to represent. It was noticeable that, during the illuminations at the national *fête* a short time back, the oil lights and the gas jets completely overpowered the electric light by the volume of light given. The electric light looked bluish white and the oil and gas were yellowish, but the electric lights were considerably inferior in volume of light given." That is a positive fact, and it is one of the most extraordinary features of the electric light. The electric light is most intense, but it has no volume, and therefore does not disperse itself. If you go under an electric lamp lighted, you will find that you cannot read. On this point Mr. Sugg says:—"There is great intensity of light in a small space, but it appears to me that, unless lenses or other apparatus can be used to convert the intensity of the electric light into volume of light, it will always be inferior as a lightning agent to gas properly consumed in lights of from 100 to 300 candles. These gaslights give nearly the white pure light of daylight with scarcely any actinism. The electric light, on the contrary, is overcharged with actinism, as compared with daylight, is blue in colour, and injurious to the eyes." That I can vouch for, and there is no doubt it is injurious to sight. I found it most unpleasant. The cost of the light, as compared with gas, cannot be stated. As Mr. Sugg says:—"No effort on my part has enabled me to arrive at anything like a true idea of the relative position of the two modes of lighting. The cost of carbons (a very important item), attendance, motive power, &c., appears to be involved in the greatest obscurity." And this is the case. Mr. Sugg again says:—"All I have seen is unsatisfactory on this head, and the relative cost appears to be, as stated to me by an eminent Paris electrician (at present) a delicate question." That is a question which they cannot answer, for it has never been solved. Then Mr. Sugg continues:—"Comparing such a light with gas as it is usually burnt by the public, more especially in street lighting, no idea can be formed of their relative value. The difference is probably as great as that between the old Roman lamp and the moderator lamp of the present day." Mr. Sugg's opinion, as far as it goes, is very decided, as confirmatory of what I have stated to you—that we need have no very great fears as to our property being deteriorated by this new mode of illumination.

In the course of the discussion which ensued, some difference of opinion seemed to prevail relative to the merits of the electric light. Two or three speakers expressed their opinion that the light would be introduced sooner

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or later, but none seemed to regard its introduction as anything to be feared in the way of a competitor with the present mode of illumination.

In other parts of Mr. Sugg's report that gentleman says:—"Since last year enormous progress has been made in electric lighting; indeed, during the last few months a great amount of talent has been devoted to it, and not without a considerable measure of success. The Avenue de l'Opéra has been lighted now for some time past entirely by the electric light, on Jablochkoff's system of carbon candles. Great progress has been made in the steadiness of light in consequence principally of the improvement made in the manufacture of carbon sticks. There are now two excellent kinds of carbon suitable for electric lights, viz., Carré's, made of compressed carbon, and Gaudouin's, made from gas tar. I saw a great many of these sorts tried before the jury, and observed that those of Carré burned almost without noise. Those of Gaudouin appeared very good, and burnt very regularly, but made more noise than those of Carré. The electric lighting appears to be now of two kinds, viz., that of Jablochkoff, in which there is no mechanism, the voltaic arc being formed between two vertical carbons kept apart by plaster of Paris or a mixture of plaster and kaolin (the electric current being alternative and working in tension); and that in which the carbons are either vertical or horizontal, and are kept at the proper distance from each other by a mechanical regulator worked by clockwork, put in action by the current itself when the carbons are not close enough together to form the proper voltaic arc. In the first kind, Jablochkoff divides the electric current, working in tension, from an Alliance electric machine among four lights. As this was the order in which it was shown to the jury, I have reason to believe that it is the most successful way in which he can put his process into operation. My appreciation of the exhibition before the jury was that the light given by the four Jablochkoff candles simultaneously burning was very brilliant and steady. The illuminating power of these lights, verified by comparison with a Carcel lamp, regulated to consume 42 grammes (648 grains) of rape oil per hour, was equal to nearly 2,000 sperm candles. The photometer apparatus was not of great value as a scientific instrument, but, roughly, I saw that the light was about equal to that I have stated. Each separate light was then equal to 500 sperm candles. There was an occasional flicker, but the variations in the amount of light were not nearly so much as I had seen on other occasions. It seems evident, from a study of the details of electric lighting, that one of the first requisites to ensure anything like success is regularity of speed in the working of the motive power, in other words, the engine ought to be exclusively used for the electric lighting. A much less amount of scientific energy than that employed in the service of electricity directed to perfecting gas lighting will, I feel confident, result in a success which will be surprising, and leave far behind, as regards steadiness, whiteness, and usefulness of light, all that is likely to be done in electricity for a very considerable period."

SUBMARINE TELEGRAPH COMPANY.

The half-yearly general meeting of the proprietors in this undertaking was held on Tuesday, the 20th inst., at the City Terminus Hotel, Cannon-street, under the presidency of Sir James Carmichael, Bart., the chairman of the Board of Directors.

Mr. S. M. Clare, the secretary, read the advertisement convening the meeting, and the seal was then affixed to the register of shareholders.

The report of the directors was taken as read. It referred to a decrease of 886*l.* in the receipts as compared with those of the corresponding six months of 1877. The business, however, enabled the directors to make the usual addition to the reserve fund, and to recommend a dividend at the rate of 17 per cent. per annum.

The Chairman then said: I have great pleasure, gentlemen, in moving the adoption of the report and accounts. I trust and I hope this is the last occasion on which you will see any allusion to a falling off in our receipts; but at the same time, looking at the extraordinary times we have passed through, we have really every reason to be satisfied with the results of our business; and I think we may consider ourselves happy that our loss of traffic has been so infinitessimal, I may say. I have great pleasure, too, in telling you that since the turn of the new half year—in the last few weeks—our traffic has begun to assume its old proportions; and I have no doubt that unless any exceptional political disarrangements should take place on the Continent—which I hope will not be the case—we may look forward to our old revenue. In our report we have drawn attention to the fact that we have had inserted in the line between Jersey and France five miles of new cable, and the cost of this has been charged to the revenue of the half year. Your reserve fund, therefore, remains intact, and we have added the usual amount to the fund, which now amounts, in round figures, to 64,000*l.* That I think, is a very satisfactory figure. We are looking out in every direction to get, if we can, any increase in our business. I was happy to see in the papers the other day that a new discovery had been made which seems to beat the telephone. The telephone will convey sound to any distance, but now there has been discovered a means of conveying taste along a wire [laughter]. I look forward to that to bring profits to our company in the future.

Mr. James M. Wood, a shareholder, having formally seconded the motion, a short discussion ensued, and, in reply to questions and observations,

The Chairman said they estimated the "life" of their steamer at about 14 years. It would always be worth its money.

The Secretary said they had already 3,622*l.* to the credit of the steamer fund, and the French Company had another 1,200*l.* This made together 4,822*l.*, and the steamer cost only 15,000*l.*

The Chairman further observed that the sum of 4,822*l.* was independent of the boilers, for which they had a separate fund. They were, therefore, making provision sufficient for the steamer. He then put the motion, which was carried unanimously.

The Chairman then moved the declaration of dividend for the half year at the rate of 17 per cent. per annum.

Alderman Sir Thomas Dakin seconded the motion, which was carried unanimously.

The Hon. Ashley Ponsonby, a director, then moved the re-election, as members of the Board, of Sir James Carmichael, Bart.; and Sir Julian Goldsmid, Bart., M.P.

The motion was seconded and carried unanimously.

The retiring auditors having also been reappointed,

A vote of thanks was passed to the Chairman and directors for their satisfactory conduct of the affairs of the Company, and the meeting then separated.

MEDITERRANEAN EXTENSION TELEGRAPH COMPANY (LIMITED).

The 42nd ordinary general meeting of the shareholders in the above company was held on Wednesday, the 21st inst., at the City Terminus Hotel, Cannon-street, under the presidency of Sir James Carmichael, Bart., chairman of the board.

The report of the directors for the half year ending the 30th of June stated that there had been a sensible improvement over the working of the previous six months. They recommended the payment of the usual 8 per cent. dividend on the preference shares, less income-tax, and of 3 per cent. on the ordinary stock, free of income-tax, payable on and after the 1st prox., carrying 471*l.* 13*s.* 4*d.* to reserve fund.

The Chairman, in moving the adoption of the report and accounts, stated the report informed them of everything which had occurred since the last meeting. With regard to the cable which was injured, it was the old original cable—the Alga-Grande cable. He thought it was injured about seventeen or eighteen miles from the Sicilian coast. There was no difficulty in repairing it; but, unfortunately, the steamers which belonged to the Eastern Company, of which they hoped to avail themselves, had been very much employed lately. In the meantime their traffic went by other cables. They did not lose anything by this interruption, but it was a question of delay. They hoped in a few weeks to get a steamer, when no doubt the cable would not take more than two or three days to repair. It had been raised, and, considering the time it had been down, he did not think it was in very bad condition. With regard to the reserve fund, and the conflicting claims of the ordinary and preference shareholders, they would recollect that at the last meeting a wish was expressed by the proprietors that they should take counsel's opinion as to the exact position of that fund, or whether it belonged to the ordinary or preference shareholders, or both classes. Accordingly, their solicitor drew a case, which was shown to counsel, going through the whole matter from the beginning. This was laid before Mr. Kaye, Q.C., one of the most eminent members of the Chancery bar, and he had given his opinion on the case presented, that the ordinary and preference shareholders would be entitled to divide the assets, including the reserve fund, *pari passu*. In this opinion the solicitor of the company coincided. It was clear, therefore, from this that the reserve fund belonged to both classes. At the same time, as he had explained before, it was a fund for the maintenance of the cable, and they drew on it from time to time for the renewal of their line, which, therefore, benefited both classes. He concluded by moving the resolution.

Mr. Field having formally seconded the motion,

Mr. Robinson congratulated the meeting on the improvement in the receipts, as compared with the corresponding period of the previous year, and on the increase in the reserve fund. He spoke of the advantages to the ordinary shareholders of amalgamating the undertaking with the Eastern Extension Telegraph Company.

Mr. John Griffiths acquiesced in the last remarks of Mr. Robinson; and, in the interest of the ordinary shareholders, he urged on the directors the necessity of coming to some arrangement with the Eastern Company.

Mr. Vears thought a too gloomy view had been taken of the position of the company's affairs.

Another Shareholder advocated the policy of amalgamating the undertaking with some larger company.

The Chairman, in reply, at the close of the discussion, said he was certainly of opinion that the ordinary expenses of repairing their cable ought to come out of the half year's revenue. He could hardly anticipate what the cost of the present repair would be. Directly he heard of Cyprus coming under the protection of the British Government, he put himself in communication with the Treasury to see whether anything could be done for the extension of their system in the Mediterranean. He believed that nothing definite had been decided on as to who should have the telegraphic communication between Alexandria and Cyprus. As to the question of the amalgamation, they were always open, and since their last meeting he had been in communication with a proprietor in this company, who was also a proprietor and the legal adviser of the Eastern Extension, to see if anything could be done, and that gentleman had promised to consult with this company's legal adviser. He did not know, however, what the Eastern would do. He had heard that the company did not care to take them; but he quite agreed that it would be to the advantage of the company, and wise of them, to take them. When their solicitor returned, he would consult with him as to further communicating with Mr. Kaye, but he thought they might take it for granted that the result would be the same.

The report was then unanimously adopted, the dividends were declared, and the retiring directors and auditors were re-elected.

The meeting separated after passing a vote of thanks to the chairman and directors.

The Electric Light.—Mr. John Hollingshead writes to us as follows:—"Seeing that Mr. G. H. Stayton's report on the electric light (I presume the 'Joblockoff light') of Paris, is going the round of the papers, I have referred its statements to Mr. Mayer and the French scientific gentlemen whom I brought over from Paris to establish and manage the electric light (called the Loutin light), which I am burning every night in the Strand. Their answer, supported by elaborate details, is this: With machinery valued at 3,400*l.* they are prepared to light an area of 1,540 yards long by 44 yards wide, with 36 lamps, exactly similar to those we are now using, having all the admitted advantages of the electric light, and an illuminating power equal to 2,000 of our existing street lamps, at a cost of 10*s.* 6*d.* per hour for consumption and superintendence. Thus, in place of 109 gas lamps, the public would get a lighting power nearly twenty times greater at a cost of only five times greater than the present outlay. By reducing the number of lamps and making other alterations, the illuminating power and the cost would be reduced at the same time, until the difference between the cost of gas and electricity would be equalised, still leaving immense advantages on the side of electricity.—J. Hollingshead, 14, Pall-mall."

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NOTES.

New Applications of the Electric Light. — A correspondent has written to the *Globe* suggesting the use of the electric light in tunnels. By so doing, he says, the carriages would not require to be supplied with oil or gas, much time and labour would be saved, and a uniform light would be ensured, not leaving, as is often the case, part of the train in darkness. The carriages would be cooler, and less dirty, the driver would have a clearer view of the line, and the system would be less expensive than that at present in use. From France, we hear of harvest operations being carried on by the same light.

The Telephone in the Field.—According to the *Gazette de Cologne*, the telephone is about to be utilised in the German army. The regiment attached to the railways has been making with this apparatus some experiments, which are to be repeated by the infantry regiments. These will use the telephone for the advanced guard service. The experiments in question are facilitated by some new improvements in the telephone, which is provided with an alarum and an apparatus in imitation of the bugle, worked by a magneto-electric current. Some important reviews of the troops are to take place, and will give an opportunity for forming an opinion as to the extent to which the telephone may be utilised in military operations.

Metalic Films.—It is stated that films of gold and other metals can be obtained, by means of electricity, of sufficient thinness to transmit light. The films are obtained by causing electric sparks to pass from wires of the required metals, passing into glass tubes of rarefied air or other gases, when the particles of metal, detached from the wires by the sparks, become deposited on the glass, forming an excessively thin film, quite continuous, it is said, under the microscope. Of the metallic films thus produced gold transmits a fine green light; silver gives a fine blue colour; copper, a dull green; platinum, a bluish-grey; zinc, a deep bluish-grey; iron, a tint nearly neutral, but inclining to brownish; and cadmium, like zinc, a bluish-grey.—*Engineer.*

A Simple Phonograph.—We notice in the *Scientific American* of the 24th ult. a short description of a very simple phonograph. It consists of a mouthpiece similar to that used for a telephone, but on the under surface it has the phonographic style or needle fixed to it. Fastened on to this mouthpiece is a circular rim of wood, with two grooves opposite to each other cut in it; a piece of wood with a groove along its length accurately fits these grooves, and, when a piece of stout tinfoil is attached by bees'-wax on the surface next the needle, the wood and foil being drawn slowly along whilst a person is speaking into the mouthpiece, the usual phonographic impressions are made on the foil. In this way a very simple and inexpensive phonograph may be made.

Improvement of the Leclanche Battery.—M. Du Moncel has presented to the Academy, on the part of M. Leclanché, a new form of the battery known under the latter name. This new form is said to give a more constant current, and to be much more durable than the previous forms. The carbon plate is altogether separate from the mixture of carbon and oxide of manganese usually agglomerated with it; and the depolarising mixture in question takes the form of two plates which are applied to the two surfaces of the electrode, and are maintained in position by a couple of elastic bands. Simple contact with a fragment of the consolidated compound suffices to depolarise, in a few moments, a polarised carbon plate; and it was pointed out that this effect is due to the local current produced by the contact, and through which the hydrogen becomes oxidised by the manganic peroxide. In future, therefore, the negative element will last indefinitely, instead of being, as at present, rejected when the peroxide is exhausted—a new depolarising plate replacing the old one in contact with the carbon whenever it may be necessary.

British Association.—The following are the titles of papers on electrical subjects read at the late meeting of the British Association:—R. Anderson, on Lightning Conductors; Professors Ayrton and Perry, a New Determination of the Number of Electrostatic Units in the Electro-Magnetic Unit; V. Ball, M.A., on a New Geological Map of India; Professor Barrett, a New Form of Trap-door Electrometer; J. Brown, on the Theory of Voltaic Action; Professor G. Forbes, Report of the Committee on Atmospheric Electricity; J. E. H. Gordon, an Account of some Experiments on Specific Inductive Capacity, also on the Effect of Variations of Pressure on the Length of Disruptive Discharge in Air; W. Ladd, on Edmunds's Phonoscope, also on Byrne's Compound Plate Battery; Denny Lane, on a New Form of Electro-Registering Apparatus; Professors Perry and Ayrton, on the Electrical Properties of Beeswax and Lead Chloride; W. H. Preece, Recent Improvements in Telegraphic Apparatus; Isaac Roberts, F.G.S., Experiments on Filtration of Sea Water through Triassic Sandstone; J. N. Shoolbred, on Electric Lighting; Professor S. P. Thompson and Oliver J. Lodge, on Unilateral Conductivity in Tourmaline Crystals; Sir William Thomson, on Gauss's Warning Regarding the Sluggishness of Ships' Magnetism; J. R. Wigham, the Combined Gas and Electric Light for Lighthouses; W. Williams, on the Cervus Megaceros.

Effects of Electricity on Vegetation.—Probably every one who has entered a wood or a forest has noticed the stunted or scraggy growth of the underwood, and the cause of that peculiar condition has always been attributed to the fact that the shrubs or smaller trees were overshadowed by the foliage of the larger ones and deprived of the light and air necessary to their full developement. M. Grandeau, Professor of the Ecole Forestière, states that his researches on the subject led him to the conclusion that, although a certain effect was to be attributed to that cause, it was not sufficient to account for the great depreciation in the vegetation. After long reflection he came to the conclusion that the large trees acted as conductors of electricity, and thus deprived the undergrowth of an element necessary to their full developement. In order to test his views, he tried a series of experiments on various plants, but we need only refer to one, which, although not the most striking, will fully elucidate the principle he advances, the means he employed, and the results obtained. In April, 1877, he took two tobacco-plants, each weighing $3\frac{1}{2}$ grammes and having four leaves. They were both planted in boxes containing mould of identical quality, and placed side by side in a position favourable to their growth. But one of them had placed over it a cage, consisting of four iron rods 1 metre 50 centimetres high, joined at the top and covered with wire gauze, which permitted the free circulation of air, light, and water, but completely protected the plant from the action of atmospheric electricity. They were left uninterfered with until the middle of August, when the results obtained were as follows:—The plant in the open air had attained a height of 3 feet 5 inches, while the other was only 2 feet 4 inches; the former weighed 273 grammes, and the latter 140 grammes; when dried their respective weights were 30 grammes and $15\frac{1}{2}$ grammes. Similar experiments made with maize and

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wheat gave precisely analogous results, so that M. Grandeau has come to the conclusion that the electricity of the atmosphere is equally necessary to vegetation as sunlight, air, and water.—*Galignani's Messenger.*

Edmunds' Phonoscope.—Mr. W. Ladd read a paper with this title at the Dublin meeting of the British Association, of which the following is an abstract:—"This little instrument, the phonoscope, is for producing figures of light from vibrations of sound. It consists essentially of three parts, an induction coil, an interrupter, and a rotary vacuum tube. The action of the instrument is as follows:—Sounds from the voice or other sources produce vibrations on the diaphragm of the interrupter, which, being in the primary circuit of the induction coil, induce at each interruption a current in the secondary coil similar to the action of a contact-breaker or rheotoine; therefore, each vibration is made visible as a flash in the vacuum tube. This tube revolving all the time at a constant speed, the flashes produce a symmetrical figure like the spokes of a wheel, as in the Gassiot Star. The number of spokes or radii is according to the number of vibrations in the interrupter during a revolution of the tube, and the number of vibrations being varied to any extent according to the sounds produced, the figures in the revolving tube will be varied accordingly. The same sounds always produce the same figures, providing the revolution be constant. In case of rythmical interruption being produced in a given sound, as in a trill, most beautiful effects are noticeable, owing to the omission of certain radii in regular positions in the figure. The uses of this instrument are the rendering visible of sounds, and showing the vibrations required in their production, and it forms a mode of confirming by sight an appeal to the ear."—The following is an abstract of another paper by the same author:—"Byrne's Compound Plate Battery: This battery is the invention of Dr. Byrne, of Brooklyn, America. Its chief features are a compound negative plate and a simple mechanical means for preventing polarisation. It is much used in the States for surgical operations, its extreme portability and control rendering it peculiarly useful in this direction. A battery of four small cells will heat nine inches of No. 16 platinum wire to redness. The inventor states that he has driven a heavy Singer sewing machine for eight hours a day at a cost of twopence. As yet nothing has been done in this direction in England."

On Galvanic Currents between Solutions of Different Degrees of Concentration of the Same Substance, and their Series of Tensions. By Dr. James Moser.—The electromotive force of liquid galvanic series is influenced by the concentration of the liquids. In order to determine the nature of this influence, I have investigated, in the laboratory of Professor Helmholtz, liquids with which it is possible to isolate this influence of the concentration. All chemical processes were to be excluded; therefore, only differences of concentration might exist, or changes in it occur during the passage of the current. Likewise, for the elimination of all chemical actions, it was necessary that the electrodes should consist of that metal which was contained in the solution. Two glasses with differently concentrated solutions of the same salt were connected by a siphon; and the circuit was closed by a metallic conduction with the electrodes just mentioned. I then observed, in all the cases investigated, *that a current arises which proceeds from the more dilute to the more concentrated solution.* It may be represented thus:—

$$\text{Zn, dilute Zn SO}_4\text{, concentrated ZnSO}_4\text{, Zn.}$$

This current appeared regularly in a series of solutions of sulphate, nitrate, chloride, and acetate of zinc, sulphate and nitrate of copper, chloride of iron, acetate, and nitrate of silver, &c. I observed the electromotive forces of these series by Poggendorff's method of compensation, modified by Du Bois-Reymond, from a few thousandths up to one-fifth of a Daniell, the latter force between very dilute and highly concentrated solutions of zinc chloride. I give, in the following table, the ten electromotive forces, between the combinations of two, of five solutions of sulphate of zinc, the unit being nearly 0·001 of a Daniell:—

100 parts of solution contain of $ZnSO_4+7H_2O$	15 per cent.	30 per cent.	45 per cent.	60 per cent.
1 per cent.	18	22	28	36
15 ,,	...	5	13	21
30 ,,	...	...	7	17
45 ,,	...	...	...	9

These numbers indicate a series of tensions; for, *e.g.*, the electromotive force between 15- and 30-per-cent. solution is 5, 30- and 60-per-cent. solution 17, 15- and 60-per-cent. solution 21. I then confirmed the existence of a series of tensions, by connecting with each other, by four siphons, five glasses, of which the 1st, 3rd, and 5th contained solutions of equal strength (45 per cent.), the second contained stronger solution (60 per cent.), the 4th weaker (15 per cent.). I immersed the one electrode in glass 1, the other successively in 2, 3, 4, 5. When the second electrode dipped in 3 and 5 I obtained no current, because the concentrations of the terminal solutions were equal; but, on the immersion of this electrode in glass 2, and in 4, there was always a deflection produced—in the one case by the electromotive force 9, between solutions of 45 and 60 per cent., in the other by the force 13, in the opposite direction, between 45- and 15-per-cent. solutions. I made the same experiments on a series of other salts, and thus determined the 15 electromotive forces between the couples formed by six solutions of cupric sulphate:—

	B	C	D	E	F
A	10	16	21	25	27
B	...	6	11	15	17
C	...	...	5	9	11
D	...	...	...	4	6
E	...	...	...	...	2

F was a solution containing, in 100 parts, 30 of crystallized salt ($CuSO_4+5H_2O$). One hundred parts by volume of this solution were mixed in E with 33⅓, in D with 100, in C with 300, in B with 700, in A with 2,900 parts of water. By these currents, going from the diluted to the concentrated solution, metal is dissolved in the diluted, and separated from the concentrated solution. Only when the concentration is the same in both solutions does the current cease. For the work accomplished by the current we should have to seek the corresponding equivalent in the work of the force of attraction between the salt and the water, which makes itself perceptible in the thermal actions which can be observed on mixing different solutions of the same salt. Accordingly, the current observed by me must be conceived as a reaction-current against the migration of the ions, as the polarisation-current is one of reaction against the decomposition-current; for, whenever any salt is electrolysed, the solution becomes more concentrated at the anode, more dilute at the cathode. My experiments show that then arises an electromotive force which acts in opposition to that of the electrolysing battery.—*Monatsbericht der kön. preuss. Akad. d. Wissensch. z. Berlin.*

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GENERAL CONSIDERATIONS UPON TELEGRAPHIC TARIFFS.*

[CONTINUED FROM P. 149.]

Before the reductions of tariff the proportion was equal at home, and commercial communications formed 63 per cent. of the international business.

Thus it is clear that, especially in their progressive movement, communications follow the fluctuations of commerce, and are influenced by the tariff only in a very secondary degree.

As they constitute the chief object of international telegraphic relations, it is impossible by a low tariff to obtain in these relations the increase of business which the same measure would bring about in the home service.

The benefit is much smaller, since few persons profit by it.

It costs the Treasury much more, for the compensation made by the relative abundance of correspondence is not by any means the same as in the case of the home service.

Summing up, in the form of principles, the results of experience, as they have just been analysed, we may consider it proved:—

1. That a reduction of the tariff for telegrams brings about a decrease in the net returns, even under the most favourable conditions known to us.

2. That the home service, which showed a deficit before the last reductions of tariff, has obtained, by these measures, an enormous increase of business, with a slight increase of this deficit.

3. That the international service, which has always given a profit, has had, under similar measures, a much smaller increase of business, and a much more considerable decrease in the profits than the increase in the home deficit.

4. That at home the deficit tends to decrease, whilst in the international service the decrease in the profits tends to increase.

Thus the motives of public interest which determine a reduction in the home tariff are not applicable generally to the international service.

These conclusions are six years old. They have not been refuted, and the influential authorities who demanded a reduction of the international tariff have not persisted in their demand. This labour must, doubtless, have escaped the attention of many persons competent to judge of matters concerning foreign telegraphy. However, it has not remained entirely unknown, and we will quote, as testimony and confirmation, some extracts from the speech delivered by Sir James Anderson, of which we have already quoted some portions:—

"I propose to show now what Belgium has established by an experience of twenty years' working by the State, and by a more complete and systematic study of telegraphic statistics than I have been able to find elsewhere.

"I have translated and abridged this part of the report, the correct title of which should be:—'*A study of the theoretical and practical effects of tariffs on all branches of telegraphic correspondence.*'"

The speaker then gives long extracts from the Belgian statement, as well as some of the tables furnished by this statement. He reviews the statistics of other countries, and the results obtained by certain submarine or extra-European enterprises. We will confine ourselves to quoting from this review only the following passage relative to Transatlantic telegraphy, the charges and the receipts being expressed in francs.

"The gross receipts of the Atlantic Telegraph Companies, from the 28th July, 1866, to the 31st December, 1871, amounted to 54,275,000f.

"Taking an imaginary tariff at 321f. per telegram (the average of the first eleven months) and a regular annual increase of 12½ per cent., the gross receipts for the same period would have been 62,950,000f.

	Francs.
	62,950,000
"Subtract	54,275,000
"Difference in favour of a tariff at 321f.	8,675,000
"Add expenditure which would have been saved	2,425,000
"Total	11,100,000

"The successive tariffs had the following durations:—500f. from 28th July to 31st October, 1866—3 months 4 days; 250f. from 1st November, 1866, to 31st August, 1867—1 year 1 month; 131·25f. from 1st December, 1867, to 31st August, 1868—9 months; 84·40f. from 1st September, 1868, to 31st May, 1869—9 months; 50f. from 1st June, 1869, to 9th August, 1869—2 months 9 days; 37·50f. from 10th August, 1869, to 11th December, 1870—1 year 4 months; 75f. from 12th December, 1869, to 30th June, 1871—6 months 19 days; 50f. from 1st July, 1871, to 31st January, 1872—7 months.

"The above estimate takes it as granted that the average tariff for the first eleven months was maintained, and that 12 per cent. was the regular progressive ratio from year to year, which would have given for the year 1871 an average of 114 telegrams per day, less than one-fourth of the business which was actually done. This figure is so low that no one can suppose that it would not have been reached, even with the tariff at 500f.

"If this high tariff could have been kept in force, one cable would have been sufficient for such a small amount of business; the capital and the working expenses of the French Atlantic Cable would have been saved, and the Anglo-American Company would now be receiving a dividend of 27 per cent. on a capital of 41,875,000f."

After having given other instances, Sir James Anderson ends this part of his speech with these words:—

"It was not my intention, in studying the effect of tariffs, to find arguments in favour of the maintenance of a tariff for international telegrams relatively higher than that for home telegrams. I studied this subject with the sole object of obtaining data as correct as possible, and in the course of my investigations I found that Belgium had already given an answer to the question. The greatest part of my work, since I became acquainted with the Belgian statement, has consisted in examining and comparing the statistics of other countries as well as those of private companies, following the same method of investigation. I am bound to say that I have been unable to find any data which refute any of the deductions or any of the principles laid down in this complete statement."

It is not alone our national vanity which leads us to reproduce this conclusion. We quote it as a testimony, declaring ourselves ready to reproduce also any contrary testimony, if it should be offered, and considering that meanwhile our fourth question is answered satisfactorily.

5. *Is it necessary, or even desirable, that a telegraphic service should be self-supporting—that is to say, that it should cover all its expenses by the fees paid voluntarily by those who make use of it?*

As a matter of course, this question applies only to telegraphs worked by the State. As a general principle, it must be answered in the affirmative, for all classes of society do not make use of telegraphs, or, at all events, not in an equal degree. It would be hardly fair to get the expenses of this service paid by means of a tax—that is to say, partly by those who make no use of it.

It may, however, be alleged that society everywhere establishes, at the public expense and burden, public services which all do not make use of, or which are very unequally employed; and that these services, under the guise of guarantees of security or of facility for business transactions, &c., have an indirect but essentially a good effect upon the public welfare.

If telegraphs, by facilitating commercial and other transactions, increased the wealth and swelled the revenues of the exchequer without increasing individual burdens, we should be doing wrong in complaining of a deficit of a few hundred thousand francs. Moreover, the gratuitous assistance afforded by telegraphs, either in facilitating the working of the railway, or, in other countries, in official correspondence, must be deducted from the expenses, a great part of which are directly caused by this assistance.

These considerations ought to be examined carefully, if, in order to render telegraphs self-supporting, it were necessary to raise the tariff to such an extent as to sensibly diminish the amount of business. And for this reason we think that the question asked above cannot in every case be answered affirmatively, in the sense of an immediate and absolute necessity.

6. *Is it desirable that the returns should exceed the expenses, and bring in a permanent gain?*

We may answer this question in the affirmative, with the two following reservations:—

1. Provided that the fees which produce this profit are not such as to check the development of the correspondence, and that the returns are obtained by a large amount of business with a moderate tariff, and not by a limited amount, thanks to a very high tariff.

2. With the condition, when private enterprises are concerned, that Government control will limit the profits to the legitimate amount necessary to compensate for risks, the surplus being restored to the public in the shape of an improved service, or a reduced tariff.

We do not think it necessary to give any reasons for these two conditions. If they are fulfilled, the profits obtained usually benefit the public in the way of improvements and extensions in the service. These measures are more limited and more difficult to carry out when the net returns are negative or nothing at all.

[TO BE CONTINUED.]

* Translated from the *Journal Télégraphique.*

An important work by Mr. J. D. Reid, "The Telegraph in America," is announced for September. It is intended as a memorial volume of Prof. Samuel Morse and of William Orton.

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ON A MODIFICATION OF MANCE'S METHOD OF MEASURING BATTERY RESISTANCE.

BY O. LODGE, D.SC.

[CONCLUDED FROM P. 159.]

Elimination of Variations in Electromotive Force.—It has been stated above that if only momentary variations are made in the resistance r, or in the value of u, we can consider ϵ, the electromotive force of the battery, constant. The plan I adopt is to make the *effective* variation of r, or the variation which is to have any influence on the galvanometer, very short indeed. And this is done by arranging that the key m which closes the circuit of r shall break the galvanometer circuit g, the instant after, at the point n, as shown in figs. 9 and 11. For an instant, then, u is varied; and if the resistances are not balanced so that $ac = bd$, a certain quantity of electricity will enter or leave the condenser through the galvanometer; but variation in ϵ (due to the changed u), which would produce the same effect on the galvanometer, no matter how much the resistances were balanced, has no time to take place before the galvanometer circuit is broken; and then no further change has any effect. This works very well in practice; and the resistance of a cell can be really determined when producing a current through a definite resistance, viz., $a + b + c + d$. This cannot be done accurately by any other method that I know of.

Measurement of any Liquid Resistances.—The method may be applied to determine the resistance of electrolytes in general. A long tube containing the electrolyte surrounded by a jacket of water at a known temperature is interposed in the battery circuit d, the battery being one whose resistance is small and can be depended on; and the resistance of the two together, battery and tube, is measured.

The tube is then removed, and the resistance of the battery determined alone; the difference, of course, gives the resistance of the electrolyte in the tube. The tube can then be filled with mercury and the measurement repeated. The amount of polarisation of the electrodes is of no more consequence than the electromotive force of the battery, provided the gas given off is not allowed mechanically to obstruct the current; and the effect of variations in its amount are reduced to a minimum by the method just described for the battery. It is well to make the tube end in a couple of globular receivers with two necks, very much like Dewar's electrometer, and to plunge large electrodes into these globes (see T, fig. 12). Their position in the globes is not of very much consequence; neither is a bubble or two of gas on their surface; the principal part of the resistance is offered by the liquid in the tube. If a thermometer is kept in each receiver and the liquid be allowed to flow backwards and forwards through the tube once or twice before observing, its temperature may be known without surrounding it with a jacket. But, of course, this does not apply accurately when it is required to raise its temperature much above that of the atmosphere. Since the sensitiveness depends on the electromotive force of the battery, it is well to use one or two Grove's cells. Fig. 12 is a complete diagram of the connexions, showing the arrangement for interchanging a and b by means of a commutator, and also showing a key which will break the galvanometer circuit at the instant required and act instead of the extemporised arrangement of two keys depicted in fig. 9. The lower spring carries a block which presses up against a screw connected with the galvanometer, except when is forced down by the upper spring. This block is insulated from the spring, which carries it, but is connected with the point B. The interval elapsing between the breaking contact at m and the making at n is, and must be, utterly inappreciable. For the shortest practicable interval is sufficient to allow the currents to adjust themselves, unless a and b are extravagantly large resistances; and, if it is not exceedingly short, disturbances will occur due to variations in the battery.

The diagrams purposely show the galvanometer, and not the condenser, connected with the breaking-key n, because leakage of the condenser is sure to occur to some extent when its circuit is broken, and, in order that this may not in the least signify, one terminal of the galvanometer must be insulated.

University College, London.

THE QUADRUPLE TYPE-WRITER OF KOCH.*

(For Figs. *vide* Supplement, Aug. 10th.)

In Gräbner's quadruplex instrument each writer is in contact with the riband for 1-240th part of the revolution of the contact-cylinder. M. Koch, chief of the Telegraph Office at Chur, in his quadruplex type-writer, of which he very kindly sent me a sketch and description in February, 1876, has gone yet further; for he allows each writer to remain only just so long upon the riband as is necessary to impress on it a single letter. This is quite a new solution of the foregoing problem.

To attain this result, as may be seen from Fig. 7, four contact-cylinders, W_1, W_2, W_3, W_4, are placed on a single spindle, a a, revolving at the rate of 120 times per minute, and common to all four of the type-writers, these latter being in their construction almost the same as Hughes'. The contact cylinders are, however, first set in motion by the spindle a a as their respective Hughes' electro-magnets, A_1, A_2, A_3, A_4, receive the current, and release the anchor levers, which then key the cylinders on to the shaft. Each cylinder W, and with it also the type-wheel-axle g of the same division, then makes, just as with Hughes', a complete revolution with a a. This fixing of the contact-cylinder W to the axle a a is occasioned, however, by the same current which presses the letter which it is required to telegraph upon the Hughes', D, immediately preceding it. By this current, too, the cylinders and type-wheel axles, working in concert, are set in motion at both stations simultaneously, so that with the impression of each separate letter, the synchronous working is at once re-established. With the actuation of the succeeding division, the current interrupts itself; it has therefore always precisely the requisite duration, and no more.

At the same moment that the impressing electro-magnet D_n of one division (and the withdrawing electro-magnet A_{n+1} of the next division) is set in motion, the withdrawing electro-magnet A_n of the same division must be retired. To accomplish this each cylinder W, as is apparent from its circumference depicted in Fig. 8, has two strips of metal, N and M, insulated from W, and separated from each other; on the first work the two fingers b and c insulated from each other and fastened to i; on the second the fingers f and k also fastened to i, and so long as this is the case N places the wires w and v, drawn to b and c, M the wires u and t running from f and k, in metallic connection. Behind N and in front of M the fingers work for the whole of the rest of the circumference of the cylinder W upon insulating material. The figure shows now that, starting from W n, it is only possible to induce a current from e through D, t, k, M, f, u, x, v if W_{n+1} has completed its revolution, and if, therefore, in W_{n+1} the fingers b and c rest upon N. In this way the impression can only be made in the fourth division when the preceding ones have completed their revolutions; in other words, by one revolution of the axle a a ($\frac{1}{2}$ second) at the most four impressions can be made—one in each division. This, the most favourable conjuncture, happens when the sum of the steps which are necessary to place all four of the divisions in the position requisite for making the impression equals the total number of the signs ready in a single division. If the impression of any one sign demands a longer time, the contact cylinder W must make a longer pressure before it can release the electric current. Hence it is that the signs must be grouped according to the frequency of their recurrence, so that those oftenest repeated may be produced with the shortest pressure of the cylinder. On an average, then, considerably less than half a revolution would suffice for the impression of a single sign; so that with each revolution of the axle a a rather more than two signs might be printed, and with 120 revolutions per minute* rather more than 240 signs, that is, more than forty-eight words.

In each receiving part a contact is re-established at d (Fig. 7), between the wires s and r, and a current coming from the line flows, for example, from L in y to z, through A_2, w, b, N, c in W_2, v, x, u over f, M, k in W_1, t, through D, and in s, d, r, q to the earth; this current then leaves (through A_2) the second division, and prints (through D_1) in the first division.

In each sending part, at the pressing down of a finger-board, the connection between s and r at d is interrupted, and instead, as soon as the crank-pin F (Fig. 7) brings the cylinder W into contact with this finger-board, a contact is re-established from the cylinder to e. The current from the battery B may then be traced on the one hand (from the copper-pole) to earth; on the other hand (from the zinc-pole), through the wire p to the axle aa, and, for example, from the cylinder W_2, to e, D_2, t, over k, M, f in W_2, to u, x, v, over c, N b in W_3 over w, through A_3 and over z and y in the line L; this current prints thus in the second division (through D_2), and sets in motion at the same time the third division (through A_3). The crank-pins F, which are not insulated towards W, are, of course, distributed in the most convenient manner on the upper surface of the contact cylinder.

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* Translated from articles of Dr. Zetsche in Zingler's "Polit. Journ."

* An ordinary Hughes, with 120 revolutions per minute, will furnish 180 signs, or thirty-six words per minute, if, on an average, one-fifth of a letter is printed at each revolution. Koch's telegraph could thus form about twice as many as Hughes', but it would require also twice as many manipulators. Each of these, however, would have lighter work.

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For the thorough explanation of Fig. 7, it is only necessary to add that in it the four keyboards are denoted by C; that on the type-wheel axle *g*, besides the type-wheel *n*, there is also a correcting-wheel *m*; and, finally, that a friction-wheel (such as is used by Hughes) is quite unnecessary here.

Instead of the friction-wheel of an ordinary Hughes, in this present instrument there is only an arm fastened to the type-wheel-axle, from which in opposite directions start two spiral springs of equal span, their other ends being joined to the correcting-wheel. Then, if the correcting-cog works on the correcting-wheel and draws the latter by this means together with the type-wheel, slightly forwards or backwards, it compresses the one or the other of the springs, and this, after the cog has left the correcting-wheel, moves the latter once more backwards or forwards, as the case may be, into its normal position, so that the type-wheel at the cessation of the motion is brought to rest at "blank."

The type-wheel *n*, the paper strip, and the ink roller are in other respects constructed exactly as in the Hughes'; so, too, are the print-axle *h*, and the contrivance for establishing connection with the electro-magnets A and D. Finally, the mechanism U lies between the check-boards V, and coincides with that of Hughes; but a heavier weight and a heavier fly-wheel are necessary.

It must be noticed that the isochronous action of the instrument is much endangered by the fact that the mechanism has to drive,* as the case may be, one, two, three, or even all four contact-wheels and type-wheel-axles. From this cause, in spite of the re-establishment of synchronous action between the complementary parts after each impression, even this synchronous working may suffer from some slight difference in the construction of the two telegraphs which are being worked together. Besides which, in sending messages greater care will have to be exercised, since the contact between the crank-pin F and the depressed finger-board does not necessarily induce a current, and thus produce an impression; for that purpose is requisite, rather, a definite arrangement of the contact-cylinder (with N under *b* and *c*), but the resulting current becomes perceptible also at the station whence the message is sent, through the noise of the printing of its own apparatus.

When it is desired to use the quadruple type-writer for sending messages in opposite directions, each part must rest upon the line during a complete revolution of the axle *a a*, and then in the same part several signs could be typed during each revolution. Koch, however, is of the opinion that the carrying out of this idea will not prove to be of much value.

THE RELATIONS OF MACHINES TO FORCES.

BY PROFESSOR A. E. DOLBEAR.†

Until within forty years the conception of a machine has been that it was simply a contrivance by which force was transferred from one place to another, and the lever, the pulley, &c., were called simple machines, and the force to be transferred was mechanical force, such as the movement of a mass of matter. The turning of the crank of the grindstone, or of a steam engine, required a force which was supplied to the machine, and the efficiency of the latter was expected to be equal to the force supplied to it, minus what was lost through friction, and this has been found to hold good so far as some machines are concerned; but it does not hold good for all.

For instance, suppose that we have a Holtz electrical machine, which has a glass wheel supported upon one bearing, which may be turned rapidly by a crank and simple pulley. The glass wheel is not subject to pressure at any place, but is free in the air as a grindstone would be. Make this disc to turn rapidly, and measure in any way the force necessary to maintain the velocity. Now, electrify the paper strips, give the glass wheel the same velocity as before, gradually separating the discharge rods, and it will be found to require more force to maintain the original velocity than it required at first. Although the disc is just as free as before, the difference is very perceptible to one turning the crank, and this difference is not accounted for in the old explanation of a machine. It is evident, then, that such a machine has a different function to perform beyond that of the transference of force from the crank to the rotating disc; but in this case it is easy to see what becomes of the extra energy required. *It is made to appear as electricity.* The machine has such a *structure* as enables it to transform the mechanical force of rotation into an allied force—electricity. The force that *went into* the machine was transformed in character from simple motion of a visible mass of matter into a form as unlike itself as anything can well be—the new force, electricity, manifesting itself by attraction and repulsion of other forms of matter, by a bright spark or streaming band of light, which latter is distributed in every direction with the velocity of light, namely, 186,000 miles in a second, while in a suitable conductor the electricity will travel at the rate of 50,000 miles or more per second.

Again: take a magneto-electric machine, leaving the terminal wires apart. Turn the machine, and measure the mechanical force necessary to maintain a given speed. Then close the circuit, and it will be found that it requires much more force to turn it, though it is plain there is no more friction upon the bearings or in the air than there was before. But now a current of electricity is traversing the wire-circuit, as can be shown by its effects upon a galvanometer, or by its heating, or luminous, or other effects. Here, again, mechanical force of rotation itself has such a structure as to transform the force going into it, and give out something very different. In each of the above cases what is it that has been transformed? Motion—that is all. The machine is the same in completeness as at first. What must the product be? Motion, though of a different character. It is molecular motion instead of mass motion; but the particular form of the motion has not been well made out yet.

But there are other ways for obtaining electricity in abundance. Do these other ways offer such testimony for the character of electricity as being molecular motion? Take the case of the common battery. In every battery there are two metals, or their equivalent, with one or more fluids holding such chemical relation to one of the metals that the fluid is decomposed in its presence. Now, it is known from other sources that every molecule in every kind of matter is in a state of constant agitation, moving with very great rapidity; and in a fluid these motions take place with greater freedom than in a solid. A zinc plate immersed in dilute acid will be bombarded by millions of molecules on every side. The exterior molecules of the plate will be knocked off, and will at once enter into chemical combination with the liquid, resulting generally in the liberation of one of the elements, but the shock of stroke, the mechanical movement upon the plate, is transformed into another kind of movement, probably vibratory, which traverses the plate and conductor, and we call it electricity. At the same time, there is the reaction upon the molecule of acid, which is transferred in the opposite direction, where it is given up to the other plate, and there appears as another current going out the other wire, and these two currents exactly neutralise each other for obvious reasons, that action and reaction are equal. In point of fact, the action in almost every kind of battery is not so simple as the above, for they are not so simply constructed. But this will help one to see that even the electricity of the battery has a mechanical origin, and, therefore, a battery is simply a machine for the transformation of motion of one kind to motion of another kind. In like manner it could be shown to be true in every case where electricity appears. It is through some kind of a mechanism where energy in one form goes in, and electricity comes out. This view has a much wider field than that indicated by following out motions until traced to electricity. It leads one to expect that where any form of force is appearing, with any mechanism, that an equivalent amount of energy is going into it, even though it cannot directly be traced. The human body, for instance, is a machine for the transformation of the energy of food into the mechanical energy of locomotion, or the energy of mental effort, for neither of these can be maintained, save at the expense of the energy of food, for precisely the same reason that the Holtz machine will not give out electricity unless it be supplied with the mechanical force in rotation. The more complete definition of a machine will then be: a material structure by which force may be transmitted or transformed.

* This would be avoided if W had not, after each insertion through A, to make a complete revolution, and if D at the insertion of the type axle immediately disconnected the cylinder W from the axle *a a*. If, nevertheless, the isochronous action of the two parts which are working together is re-established after the impression of each letter, the cylinder W and the type-wheel will be drawn back mechanically, after each impression, on to the cross. In this way the production would be increased, but then the question crops up whether a simple telegraph of similar construction would not be able to produce the same amount of work as the quadruplex instrument.

† *Journal of the American Electrical Society.*

At the meeting, on Wednesday, of the Associated Chambers of Commerce, at Sheffield, resolutions were moved by Mr. Behrens that foreign telegrams ought not to cost more to the provinces than to London, that the charges generally for foreign telegrams were too high, and that the Government should take steps to secure a revision of the St. Petersburg Convention. After a short discussion a committee was appointed to communicate with the Postmaster-General on the whole question of telegraphs, and report to the February meeting.

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A SUPERANNUATION FUND.

We printed last week a letter from no less romantic a locality than the Isles of Greece, yet treating a most practical and prosaic subject, which is more welcome to our columns than any ever handled by

"The Scian and the Teian muse,
The hero's harp, the lover's lute."

Our correspondent, who is a telegraphic official in that classic region, instead of devoting his leisure to the Pyrrhic dance, or to filling high the bowl with Samian wine, has sensibly and soberly set himself to consider the future of telegraphists, and finds that they have a bad look-out, unless something be done to provide for their support when past service. He has accordingly sent us some suggestions towards the establishment of a provident fund for superannuation; and we are glad of the opportunity to show what interest we take in such questions.

Telegraphy, and still more submarine telegraphy, has been so recently called into existence, that a majority of the officials of our great cable companies have scarcely had time to look about them and reflect on their position. As yet, a superannuated telegraphist is probably as rare as a dead postboy was said to be in former days. But there are many men in the service who must now be aware that they are approaching a period of life when they will not be able to bear the strain of constant work, and that, too, after spending their best days in an occupation that has few, if any, easy and comfortable posts with which to reward veterans, and that seldom gives leisure or opportunity for making acquaintance with other ways of getting a living. At present, the companies are engaged to them for nothing more than their salaries, which Mr. Forster's letter speaks of as liberal enough to allow of saving. He proposes, then, that the *employés* should take measures to help themselves, without excluding any aid that may be afforded by the generosity of the companies.

Our correspondent, in comparing the prospects of his fellow-telegraphists with the more favourable ones of Government servants, goes into some considerations which we must point out to be unnecessary. "In some few cases," he says, "the whole of the means are supplied by Government without the *employés* ever contributing; in others, the funds are raised equally from both; and, with the remainder, the *employé* alone subscribes to the fund, and is bound to leave a percentage on his pay for securing himself a pension." But it is really all the same in the long run if an administration pays a man, say twenty-one shillings a week, and deducts five per cent. towards a superannuation fund, as if it offers a salary of twenty shillings with the prospect of a pension. The great question is whether subscription to such a fund should be voluntary or obligatory, or, practically speaking, whether the companies are to take up the matter, or leave it to the independent action of their *employés*. Mr. Forster is more to the purpose when he gives us some details of the arrangements made by foreign Governments with whose telegraphic services he is familiar. Thus, in Italy, it seems that an increased proportional subscription is required according to the amount of the salary; salaries under 800 francs are taxed at 1 per cent., under 1,200 francs at 2 per cent., under 2,000 francs at 3 per cent., and so on. In Greece unmarried men pay 7·5, and married men 10 per cent. on salaries of whatever amount, securing, after twenty years service, two-fifths, and after twenty-five years one-half of their salaries by way of pension, which allowance is also continued to the widow if she survive her husband. This seems a liberal allowance, but we are told that there is in Greece an additional pension fund to which nine-tenths of the officials voluntarily subscribe.

Without these figures few of us would have been inclined to give the Greeks credit for this prudent foresight; but the the truth is that Englishmen, who pride themselves so much on their common sense, stand in more need of having some such income tax put upon them for their own benefit. The volatile sons of the South are in fact much more saving and frugal than we fancy them. An Englishman likes to live up to his income, and does not easily deny himself any luxuries to which he may have become accustomed. When he gets a fair salary at the outset, he spends it without enough considering whether he is to expect any marked advance of income as he grows older, to meet the expense of marriage or disablement. And so, when a man dies or is laid aside, his friends have too frequent experience of that most unsatisfactory proceeding known as "handing round the hat." It is, therefore, a most desirable thing that some gentle violence should be done to the natural thoughtlessness of young officials, as is done by the administration of public institutions. And are not our great Telegraph Companies really in the position of public institutions? Certainly no less so than the Railway Companies, which have either superannuation funds of their own, or are able to associate themselves for this purpose with the officers of the Railway Clearing House. This institution has a fund, established by Act of Parliament, which seems to be a model of what is wanted in our case. Its leading provisions are as follow:— Subscription was made retrospectively voluntary, but obligatory on all *employés* on monthly salaries who should join after the establishment of the fund, irrespective of age or health. The payments are 5 per cent. on salaries, 2½ per

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cent. contributed by the Administration of the Clearing House, and the other half paid directly by the clerks themselves; the committee of management being likewise appointed equally by the authorities and the members. An actuarial calculation shows that this subscription affords a superannuation allowance of 25 per cent. on the average salary after ten years contribution, and so on, rising year by year to 67 per cent. after 45 years. Should a clerk die before receiving superannuation, his representatives get back the money paid into the fund as contributions by him, plus simple interest at four per cent. Should a clerk die while receiving superannuation, and before he has received the full amount paid into the fund as contribution by him, his representatives get back the balance. A member leaving the service also gets back his contributions (except those paid for loss of interest) as follow:—1. If of his own accord, half his contributions. 2. If dismissed from any cause, except ill-health or fraud, all his own contributions. 3. If compelled to leave on account of ill-health, before ten years membership, all his contributions and four per cent. simple interest. A member whose salary is stopped on account of ill-health may continue his membership for twelve months, if his name remain on the books of the establishment and he continue his contributions, the Clearing Committee having agreed to pay their share on behalf of such member. There is a special provision whereby clerks of ten years service or upwards may antedate their subscription, and so earlier become entitled to superannuation, the object being that they may be placed as nearly as may be on an equal footing with new clerks. Provision is made whereby any member leaving the service of one subscribing company or committee for that of some other subscribing company or committee may do so without his membership being affected thereby. This fund has now been in working for five years. Up to the end of last year 3,180 members had entered it, of whom 58 had died and 558 had retired.

No reason is apparent why a similar arrangement should not be made for the welfare of telegraphists. In every sense it would be a mutual benefit fund. The public, the shareholders, and the staff would all profit by any means which, on the one hand, gave the companies a hold on the service of good men, and, on the other, bound the latter to a responsible and promising employment. We are, therefore, glad to be able to inform our correspondent that the subject is at present being considered by the Boards of, at least, two of the leading companies. We hope the result may be some scheme for putting their telegraphists on the same advantageous footing as the staffs of the Railways.

ON THE STUDY OF ELECTRICITY AS A PROFESSIONAL PURSUIT.

BY THOMAS T. P. BRUCE WARREN.

(CONTINUED FROM P. 129.)

VIII.

Were it not for the great liability which stannous chloride possesses of varying from one day to another, it would afford the most convenient method of testing sulphate of copper, notwithstanding the possibility of an error from the iron which may be present.

If sulphate of copper contain only one or two per cent. of iron, as a ferrous salt, and its solution be heated in contact with air, one-third of the iron will be precipitated as ferric hydrate, the iron still remaining in solution, being in the form of per-sulphate.

The principal objection consists in a want of accuracy in the iron estimation, which is found in the ferrous and ferric states. If the copper solution be boiled for a long time with an excess of hydrochloric acid, the iron will ultimately be all converted into ferric chloride and ferric sulphate. The titration with stannous chloride will then give an accurate indication of the copper and iron together. What is really required is to estimate the iron after the separation of the copper, the iron being in the same condition as before. Another fact equally prominent in importance is that solution of iron as ferrous salts in presence of hydrochloric acid is readily oxidized, and consequently may give rise to an error when titrating with the permanganate solution. This will make the quantity of iron appear less than it really is, from the possible liberation of chlorine, which will help to oxidize the iron. The following precautions suggest themselves from this reasoning:—

The solution of sulphate to which the hydrochloric acid is added should be well boiled, so as to ensure the conversion of the iron into ferric salts. Oxidizing agents, such as chlorine, nitric acid, &c., cannot be safely employed unless the removal of the excess can be absolutely ensured, since they would, by acting on the stannous chloride make the result too high. On the other hand, the iron being partly in the form of ferrous and ferric salts, the stannous chloride used would be too low when we come to deduct the quantity due for converting the ferric iron into ferrous iron.

The process itself is incapable of dealing with the next difficulty. As, however, the error need not be great, unless much iron is present, and the value of a sample of blue-stone depends upon the amount of copper present, the difference in the estimation of the iron may be discarded.

If the student, however, aims at accuracy, I would direct his attention to the following remarks by Fresenius*:—

"*Process to be Used with Hydrochloric Solutions of Iron.*—In titrating hydrochloric acid solutions of iron with permanganate, it is essential that the standardising of the reagent and the actual analysis be performed under the same circumstances as regards *dilution, amount of acid, and temperature.* Besides the proper reaction $10\ Fe\ O + Mn_2\ O_7 = 5\ Fe_2\ O_3 + 2\ Mn\ O$, the collateral reaction $7\ HCl + Mn_2\ O_7 = 5\ Cl + 2\ (Mn\ Cl) + 7\ HO$ also takes place, in consequence of which a little chlorine is liberated. This chlorine does not oxidise the protoxide of iron in a case of considerable dilution, but there occurs a condition of equilibrium in the fluid containing protoxide of iron, chlorine and hydrochloric acid, which is destroyed by addition of a further quantity of either body (Löwenthal and Lenssen). But, since it is difficult to observe the above conditions of obtaining correct results, the estimation of hydrochloric acid solutions of iron is always less trustworthy than the estimation of sulphuric acid solutions.

"The following method I have, however, found to give the best results:—

"Standardise the permanganate by means of iron dissolved in dilute sulphuric acid, make the iron solution to be tested up to ¼ litre, add 50 c.c. to a large quantity of water, acidified with sulphuric acid (about 1 litre), titrate with permanganate, then again add 50 c.c. of the iron solution and titrate again, &c. &c. The numbers obtained at the third and fourth time are taken. These are constant, whilst the number obtained the first time, and sometimes also the second time, differs. The result, multiplied by 5, gives exactly the quantity of permanganate proportional to the amount of protoxide of iron present."

These precautions will ensure the more reliable results as to the quantity of iron found in the solution after the removal of the copper; but, since sulphate of copper contains both the proto and persalts of iron, we cannot obtain by this method more than an approximative determination of the iron present.

I would advise the student to make himself familiar with this method in its simplest form, to adopt then the precautions pointed out by Fresenius. I would then suggest, as an exercise for his chemical talent, that there are methods for estimating the quantities of the two oxides of iron when they exist together.

In many cases it is sufficient to know the relative purity of a compound, especially when the contaminating material exerts no action detrimental to the purpose for which the compound itself is intended.

During the last few years a new art has been developed, which may be termed "Ars Sophictica," and I certainly know of nothing more interesting than a search among the arcana of adulterations.

There are several methods of preserving stannous chloride solution, and of filling burettes so as to avoid mixing with air.

The following simple arrangement I find answers as well as any, and is less costly than the more cumbersome and elaborate plans by which the liquid is driven out by the pressure from carbonic acid, hydrogen, &c.; and it is further applicable for caustic alkalies, acids, &c.

A wide-mouthed bottle is fitted with a good tight cork, in which are two perforations for inserting glass tubes; the cork is well boiled in melted paraffin wax.

One of the tubes reaches nearly to the bottom of the liquid;

* "Quantitative Analysis." 6th Edit. Vol. 1, page 219.

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the other tube extends a short distance beyond the cork into the bottle, and has attached to it a little india-rubber air ball. A flexible tube and mouthpiece are attached to the outer end, and by gently blowing so as to distend the ball sufficient pressure is produced to drive the liquid into the burette.

I may incidentally remark here that I find small ebonite tubing an extremely convenient substitute for glass tubing. It is easily bent by being warmed over a gas flame, and is not so easily broken as glass.

To the end of the delivery tube is attached a short piece of rubber tubing to connect to the burette; when not so required it can be closed by a pinch-cock.

Burettes, bent at the end so as to deliver their contents into a beaker without being heated when liquids have to be tested at the boiling point or any high temperature, are very convenient, though the same result may be obtained equally well by a small piece of rubber tubing.

The method of preparing the standard solution of iron will be given when dealing with zinc and its compounds.

The double sulphate of iron and ammonia is very generally employed for the same purpose. As, however, this salt requires testing for the amount of iron present, it is scarcely so convenient for the commencement of such determinations.

An example will render the working of this test more simple.

A solution of stannous chloride was prepared, and, on titrating with a solution of pure cupric sulphate, it was found that 0·1 gramme of copper required 18·8 c.c. of the stannous chloride.

To determine the measure required for an iron persalt we have to multiply 18·8 by $\frac{63\cdot5}{56\cdot0}$ $\left(\text{or } \frac{\text{equiv. weight of copper}}{\text{equiv. weight of iron}}\right)$. This will give 21·6 c.c. of stannous chloride for 0·1 gramme of iron.

A solution of permanganate of potash was made, and, on titrating, it was found that 11·5 c.c. of the solution was required to peroxidise 0·1 gramme of pure iron in a ferrous solution.

One gramme of commercial sulphate of copper was dissolved in about 50 c.c. of distilled water, and to the solution 15 c.c. hydrochloric acid was added. The whole was well boiled for some time, so as to ensure the conversion of the iron salts into the ferric form.

The stannous chloride is then run in from a burette at such a rate as not to take the sulphate solution "off the boil," until the green color had nearly disappeared, when it was added by drops.

It required 48·24 c.c. of the stannous chloride to effect the final reaction.

Another gramme of the commercial sulphate was dissolved, and boiled with pure zinc and hydrochloric acid until the reduction of the copper was complete, by which process the iron becomes converted into ferrous chloride, &c. The liquid filtered off required 0·9 c.c. permanganate solution, consequently $\frac{\cdot9}{11\cdot5} \times \cdot1 = \cdot008$ gramme metallic iron. This amount of iron as perchloride requires 1·70 c.c. of the stannous chloride, from which we arrive at the quantity required for the conversion of the cupric salt into the cuprous salt.

Total stannous chloride solution required		48·24 c.c.
For iron ,, ,, ,, ,,		1·70 c.c.
Leaving for copper ,, ,,		46·54 c.c.

As 18·8 c.c. stannous chloride = 0·1 gramme,

$\frac{46\cdot54}{18\cdot8}$ = ·248 grammes copper (metallic), which is ·007 grammes less than required by the formula for the pure salt.

The sulphuric acid, determined as sulphate of baryta, gave ·290 gramme.

The analysis stands thus:—

Copper, metallic	·248 =	cupric oxide	·311
Iron ,,	·012 =	ferrous oxide	·015
Sulphuric acid	·290 =	sulphuric acid	·290
		Loss, water, &c.	·384
			1·000

The pure salt should yield:—

Copper, metallic	·255 =	cupric oxide	·319
Iron	nil	ferrous oxide	nil
Sulphuric acid	·321	sulphuric acid	·321
Water		water	·360
			1·000

One gramme pure cupric sulphate should yield ·254 of cupric sulphide.

To prepare a solution of pure cupric sulphate:—10 grammes of pure galvanoplastic copper is dissolved in dilute nitric acid, free from iron, the excess of acid is removed by evaporation. Strong sulphuric acid is added, and the whole well boiled so as to expel every trace of nitric acid. The solution should be made up to the litre, and then cooled to 60° F., and well shaken up. 25·5 c.c. of this solution will contain the exact quantity of metallic copper in one gramme of pure cupric sulphate.

Let A represent the measure of cuprous stannate used in titrating 25·5 c.c. of this standard cupric sulphate; then, if B be the measure of stannous chloride used in titrating one gramme of sulphate of copper, then $\frac{B}{A} \times 100$ = the percentage of pure copper sulphate in the sample under test.

A simple method of testing sulphate of copper, which I think will commend itself to the electrician who requires only to know the commercial value of his sample, may be compounded from the processes previously given.

Dissolve one gramme of the salt in about 10 c.c. water, add pure hydrochloric acid, and about 5 grammes pure zinc; wash the precipitated copper so as to free it from all adhering iron solution, and decant; repeat, making sure that the iron is well washed out. Add dilute nitric acid so as to dissolve the copper thoroughly; pour in strong sulphuric acid to expel all the nitric acid, and boil until the dense fumes of sulphuric acid are distinctly visible.

Titrate this solution, and the measure of stannous chloride × 100 will express the percentage of the pure salt present in the sample.

Water must be added so as to render the solution of the acid mixture complete. The only precautions necessary to give are: Titrate under the same conditions as regards bulks of liquid and temperature, *and complete the tests as nearly as possible in the same space of time.*

In purchasing sulphate of copper, the only stipulation which appears to me should be enforced is that the salt should contain a certain percentage of the chemically pure salt as expressed in its formula of constitution, and this may always be measured by the quantity of copper it contains. Copper being dearer than iron or water, we need never be in fear that chemists will give us more than the *quantum suf.* of copper.

[TO BE CONTINUED.]

STUDENTS' COLUMNS.

GALVANOMETERS. II.—By J. T. Sprague, M.S.T.E.

(CONTINUED FROM PAGE 129.)

It is commonly stated that, when a galvanic current passes along a wire, it renders that wire magnetic. This statement, while true, is apt to mislead unless the distinction between the magnetic conditions of such a wire and an ordinary magnetic bar is clearly understood. It is frequently said that the wire attracts iron filings, but in my own experiments I have not found this to be the case within the limits I have tried. When the wire is passed through a hole in a card sprinkled with filings they arrange themselves in concentric circles around the wire, thus exhibiting the fact, proved by many other circumstances, that the magnetic condition of the wire is that of a series of closed magnetic molecules around the circumference of the wire, instead of an open series along the length, as in a magnetic bar. The explanation of this is that magnetism is a force acting radially in all directions from molecules which are transmitting electricity along the length of the conductor; as a consequence there is no external polarity or difference of tendency in the different parts or sides of the wire, but what directive power it exerts is alike in all directions and is a circumferential action. The analogies between the conditions of a closed electric circuit and this magnetism in electric conductors would be an interesting subject of study, but would lead us away from the particular object in view. There is, however, an attractive force in this circular magnetic field, for I have suspended a magnetic needle to a delicate balance, and then, having arranged a wire at right angles, so as to avoid disturbance by the motion of deflection, I have found that, in all positions, the needle is drawn towards the wire. On a future occasion I purpose following this subject out.

The action which concerns us at present is that observed by Oersted in 1820, and worked out by Ampère, and which is the foundation of electro-magnetism and of telegraphy, and upon which are based all the existing forms of galvanometers. When a magnetic needle and a galvanic conductor are placed parallel with each other, they tend to place themselves at right angles to each other; the action is reciprocal, either the magnet or conductor will move. We have here two subjects to consider—(1.) The direction of the motions produced, and (2) the forces at work. The simplest apparatus for the study of these (having also many other uses in the study of electro-magnetism) is

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Ampère's stand, shown in Fig. 1, so that any one can easily construct it. It consists of two rods (best made of copper, but which may be wood, with a wire carried along them) mounted, close to each other, on a wooden stand, and provided with binding screws; in the end of each of these rods is sunk a conical hole, the two being in an exact vertical line. Wire frames adapted to different purposes are arranged to swing from these rods, the best mode of pivotting them being to pass a needle-point through the end of the wire, just long enough to rest in the bottom of the conical hole; a globule of mercury in the hole makes good connection. The wire shown is a rectangular frame, constituting a galvanic circuit, the action of whose vertical and horizontal components can be separately examined. A separate stand and arm, with either an adjustable pivot or a silk fibre to support the needle in any required position, completes the apparatus. To examine the motions of the needle alone a

FIG. 1

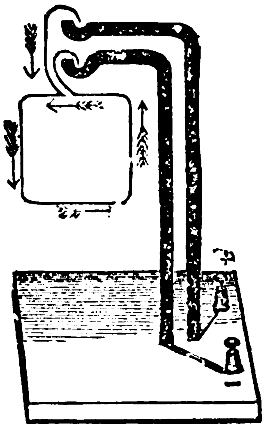


FIG. 4

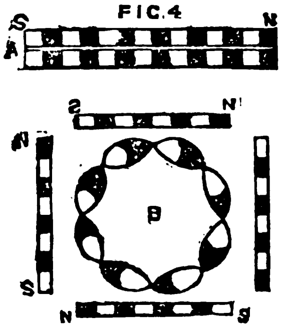
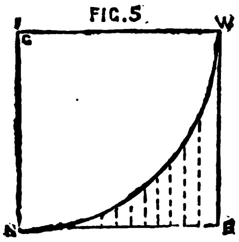


FIG. 5.



similar arrangement can be made of one piece of wire only, bent in the form shewn and provided with connections; but the first examination is, of course, most easily made by means of a long straight wire raised some distance from the table in a N. and S. line, into the neighbourhood of which the magnetic needle can be brought. Fig. 2 is a cross section, and fig. 3 a plan view of such a wire.

The arrows in all the figures to be used shew the course of the current from the + pole or connection of the battery, and of course the end of the wire led to a + terminal is itself in a state of — polarization as shewn in fig 2. Magnets range themselves in the positions shewn, the N end moving in the same direction as the hands of a clock; it will be seen from fig. 2 that this means that they range themselves tangentially to the circular magnetic

FIG. 2

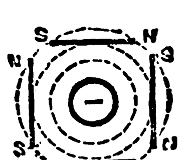
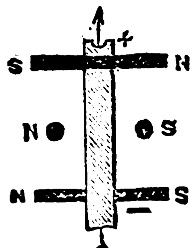


FIG. 3



system of the wire, just as it was stated that the particles of iron filings do. By fixing this representation in the mind, the motions of the magnet can always be remembered, viz, that, looking along a wire from its + connection, or in the direction of the supposed current, the N. end always moves round the wire with the clock; if the current be reversed, so is the motion; if the conductor is moveable and the needle fixed, the conductor moves in the reverse direction to that which the magnet would take. Fig. 4 is an attempt to give a visible explanation of the cause of these movements. A magnet is usually represented as a system of polarized molecules ranged lengthwise as shewn in A.

If B is regarded as a section of the wire, showing its magnetic system as a closed circle of the same character as the bar A, we may see that the magnets range themselves as they do in order to bring their own polar systems and magnetic fields into a uniform arrangement with that of the wire.

In considering the directive influence or tendency to motion, we have, of course, left out of sight any resistance to motion. But, without a resistance, there could be no measurement. In practice, therefore, we have to overcome a known resistance which, in the case of single magnetic needles, is the directive influence of the earth. In other cases a mechanical resistance by torsion, or by a bifilar suspension, or, in vertical galvanometers, the lifting of a weight are employed to measure the power employed. The ideal galvanometer would be one in which, 1, the reaction between the two systems should be equal in all positions; 2, the resistance to motion should be equal in all positions or, 3, these should vary inversely with each other. In such an instrument equal movements would indicate equal increments of power, and the scale would be one of equal parts, such as the degrees of arc. But these conditions do not exist. The resistance of a magnet to motion increases with its deflection. To simplify matters, we may consider only one-half the needle so as to regard it as a lever of the second order, with its fulcrum at the point of suspension.

In Fig. 5, C N represents this half needle, and it will be seen that the pull of the earth's magnetism may be represented by the vertical dotted lines at any point between the line N E and the arc N W, the full power exerted when the needle stands E and W being evidently much more than double that exerted at half the deflection. The action thus shown is, in fact, in the ratio of the versed sine of the angle of deflection. The force exerted by the current (being evidently a radiant one) varies, as regards the action of each molecular constituent of the circuit, in the inverse ratio of the squares of the distances; but, as regards the sum of the actions, it varies in a much more complicated manner, dependent upon the particular construction in each individual case. In the simple case of a long, straight conductor, the force varies directly as the distance, and, when this fact is analysed, it is found to be a natural consequence, or resultant, of the several actions exerted by the separate molecular constituents of the conductor and magnet. The varying powers exerted by the current under different arrangements will be studied as they arise in the different forms of instruments.

[TO BE CONTINUED.]

QUERY.

Can any of your readers describe to me any arrangement to decompose water rapidly with a single Wollaston cell? I am told that such an arrangement is quite practicable. L. A. D.

LITERATURE.

POSTS AND TELEGRAPHS.

Posts and Telegraphs, Past and Present; with an Account of the Telephone and Phonograph. By William Tegg, F.R.H.S. London: W. Tegg and Co.

Le Télégraphe: Terrestre, Sous-marin, Pneumatique. Paris: J. Rothschild and Co.

The latter part of Mr. Tegg's book was issued a few weeks ago to meet the public interest in the recent inventions of which it treats, and it was then noticed in our columns. The whole work now appears in a form which is at once handsome and appropriate, the binding being ornamented with an imitation of a stamped and addressed envelope. The contents seem to be equally well suited to their object, giving a popular account of the history and present position of our postal and telegraph communications. In treating of the telegraphic signals in use before the discovery of electricity, we think Mr. Tegg might have been a little fuller, especially as he has included a good deal of matter no more germane to his purpose—*e.g.*, several pages filled with the instances in which letters are mentioned in the Bible and Apocrypha. By consulting some such work as "Gamble's Essay on Telegraphic Signals" he could have given a good deal of curious information on a subject which is so interesting and so little known that we may before long devote an article to it. Then, in quoting Glanvil's and Strada's remarkable foreshadowings of the electric telegraph, our author does not note that something of the same kind might be said of the great Galileo. But most readers will not quarrel with him on this score, since he gives a clear account of the telegraph as it is to-day; nor will those for whom it is designed object that the information is conveyed in a somewhat scrappy and discursive form. Mr. Tegg's compilation is certainly readable, and appears to be correctly written up to date.

The French work, however, which lies before us will be more interesting to real students of electricity. Dealing solely with the telegraph, it gives a full and lucid account of it, historical as well as scientific. The author is thoroughly versed both in the theoretical and practical part of his subject; and, as we could scarcely desire a better book of the same size to put into the hands of the young electrician, we should welcome a translation of it into English. Equal praise may be given to the illustrations, which are abundant and useful. The only defect we find is that, having appeared last year, it contains no account of the new wonders which have recently excited the electrical world.

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THE BRITISH ASSOCIATION.

Section A—DEPARTMENT OF PHYSICAL SCIENCE.

This department was under the presidency of Dr. Hirst, F.R.S.

The chairman called upon Professor W. E. Ayrton and J. Perry to read their paper "On a New Determination of the Number of Electrostatic Units in the Electro-Magnetic Unit."

Professor AYRTON, of Japan, said: As I am at the present time separated from my laboratory and all my apparatus by practically half the world, and as all my books are on the voyage home, I must ask the section to consider this as only a preliminary account of my investigations. I hope to give further results during the year. When the committee of the British Association for reporting on electric standards commenced their labours some sixteen years ago they felt, as electricians had done before them, that it was desirable to develope two distinct systems of electric units, the electrostatic and the electromagnetic. Both these systems may be called absolute systems depending on mass-weight and current, the two systems differing in their determination. In the electrostatic it was the unit of electric quantity that was first determined; but in the electro-magnetic system the unit of magnetism was first determined. That was, the determination of the unit of current depending on the unit-pole and the electro-magnetic unit of quantity was a derived-unit from the unit of current. It was very important to determine the ratio of these two units. Now, these two units of electric quantity differed essentially from the units of length and of mass. If you take a yard and a foot, two units of length, and divide one by the other, you get a simple number three; or, if you take two units of weight—a ton and a pound—you get a simple number 2,240; but, if you divide the electrostatic by the electro-magnetic unit, it is more like dividing a solid by an area; you do not get a solid, or an area, or a number; but you get a line, a length, or, if you divide the electrostatic by the electromagnetic unit, you get a totally distinct quantity—namely, velocity, an absolute velocity, a velocity which does not depend at all upon that unit you adopt for length or time. The first determination of this velocity as the ratio of the electromagnetic to the electrostatic unit was made in 1856 by Messrs. Weber and Kolrausch, and they obtained as an answer 311,000,000 metres per second. This number strictly agreed with the velocity that had been arrived at by Foucault for light, which was 298,000,000 metres per second. There is, however, a considerable discrepancy between the two. The next determination of this important electric essential was made by Sir William Thomson in 1868, and he arrived at the result, 288,000,000 metres per second. His result is considerably less than the one arrived at by Weber and Kolrausch. By their method a very serious difficulty was noticed arising from electric absorption. I may mention, electric absorption is one of the things that puzzle electricians, namely, the sucking in of electricity into a dielectric-like glass. Weber was troubled with this, and it made his ratio too large. We are not surprised to find that Sir William Thomson, experimenting in 1868 in a totally distinct way, got as an answer 282,000,000 per second. On the other hand, Sir William Thomson had some advantages, and his notes differed between 275 and 292 millions per second. Professor Clarke Maxwell, some two or three year afterwards, took up the investigation by a method differing somewhat from that adopted by Sir William Thomson, but not altogether; and he obtained an answer differing between 284 and 294 millions of metres per second, giving a mean of 288 millions of metres per second. This number is considerably less than the number by Weber and Kolrausch. We should expect that this number—288 millions of metres per second—should be better than the mean obtained by Sir Wm. Thomson, which was 282 millions of metres per second. On the report of the British Association, page 84, it will be found that there are five distinct methods for determining this velocity—first, by a common measure of quantity that was proposed and adopted by Weber; second, by a comparison of the measure of electromotive force—the method carried out by Sir William Thomson and, in a slightly different way, by Professor Clerk Maxwell; third, by a common measure of resistance. I doubt whether we should get much out of that, because the measurement of resistance in an electrostatic measure is not susceptible of any amount of accuracy. The fourth method is by a comparison of currents. I believe this fourth method will give accurate results, but it has never been tried yet. The fifth method is by a common measure of capacity. This has never been tried yet since Professor Perry and myself took it in hand, and a comparison shows this method is the most likely to give satisfactory results. The equation will be this way:—$s = v^2$ S; where s = the electrostatic capacity of the condenser, and S = the electro-magnetic capacity of the condenser, or, following the process of Professor Fleming Jenkin, we arrive at an equation in this form:—

$$\frac{A}{4\pi t} = \frac{v^2 \, P \, \text{sin. sin.} \, \frac{1}{2} \, d'}{\pi \times r \times o \times d}.$$

A = the area of the large condenser, t the distance in centimetres between the two plates, v^2 is the number we wish to determine. $\frac{A}{4\pi t}$ all follow from the dimensions of the condenser which gives us the electrostatic capacity. The electro-magnetic capacity is measured by charging this condenser with a certain battery, and discharging it through a ballistic galvanometer, one in which the needle suffers very little damping. If we use a needle in a galvanometer which suffers very little retardation or air-damping, it will go on swinging for a very long period; then such a galvanometer is very suitable for measuring an electric shock on a sudden discharge of a condenser. d' is the deflection produced by the galvanometer when the condenser is suddenly discharged from it; d is the constant deflection produced by this galvanometer when the same battery sends a constant current through it; r is the resistance in ohms interposed in current; d, o, and r are numbers we can measure; P is the periodic time of the needle. It is very easy to make the needle suffer very little damping by weighting it; but, if you do so, you manifestly diminish the sensibility of the arrangement. This condenser, on the other hand, even if it was very large, with an area of 1324·96 centimetres—possibly the largest that has been made—still, it is of very small capacity. You have the two difficulties—you want to get a galvanometer ballistic that it shall suffer no air retardation, partly that the formula should be true, partly that we may get P; on the other hand, we want it sufficiently sensitive to measure the capacity of this condenser. When you use a moderate number of cells—three or four hundred was all I could get—this occupied me a very long time, months. I had a very good galvanometer, but not a ballistic. The needle was an ordinary needle, having a mica vein. I tried all sorts of needles, one after the other, and had to abandon them. Either there was not sufficient delicacy, either when I discharged my condenser, I got so small a deflection that you could not read it accurately; or, on the other hand, there was too much damping to allow me to use this formula with accuracy. I tried increasing the number of needles, first with four at each end. I ended by having 40 magnets above and below; in fact, I ended by having a spherical magnetic mass, all separated from one another, so that the result was a sphere magnetised to such a ratio. By building up the sphere I was able to get a spherical magnetic mass, and we know a sphere rotating in air is the body that experiences least viscous resistance, at the same time it has considerable mass and delicacy, because it is all magnetic. In the first place, I completed the sphere with segments cut from a small wooden sphere so as to make it spherical. The first result I was able to get was, although I had been working at it for a very long period, on June 18th, when the mean value attained for v was 297·4 millions of metres per second; you will observe not higher than Weber, but much higher than Sir William Thomson or Professor Clerk Maxwell. I had, however, the half Napierian logarithmical decament, which was ·12095; this is the measure of the viscous resistance to motion. I did not like this, and took this needle all to pieces again and fitted it up again, replacing small sections of a wooden sphere by sections of a hollow leaden sphere, which was the best thing I could get. I got comparatively little weight, because it was hollow, and I got it spherical; this brought the half Napierian logarithmical decament down to ·07825. In the first place, I got the periodic time 23·5 seconds; in this case the periodic time was 39·5 seconds. I now got an answer for v 299·5 millions of metres per second, not very different from the first. I made another set of determinations—of course, I am giving merely the mean value—on June 25, when I got 297·2. I am sorry to say I could not get more, because that was the day I left Japan. If you get the mean of these three, you get as an answer 298,000,000 metres. Now, the interesting thing is, this is exactly the velocity obtained by Foucault for light; this is a probable error of perhaps one per cent., so that it may be 299 or 300. Cornu, I believe, obtained about 300,000,000 metres. M. Fissot got a different answer; but we know his determinations are not near as correct as those of Foucault.

Professor AYRTON then gave a description by diagrams on the black board of the apparatus he had used, and then gave details of his results. On June 18th the area of the plate was 1,324·96 centimetres, distance between plates was 1·024, the weight of needle was 2·15 grammes, periodic time P was 25·3 seconds, half Napierian logarithm, ·0012095, mean value for v for a number of discharges of the condenser was 297·4 millions of metres per second. June 23rd, with the needle of the wooden sphere, but with 40 needles: Area = 1323·14 centimetres, distance between plates ·7723, weight 3·4 grammes, periodic time 39·5, half Napierian logarithm ·07825, mean value for v. 299·5 millions of metres. June 25th: area 1323.14, distance ·7728, weight, 3·4, periodic time 42·2, half Napierian logarithm 0·081865, value of v 297·2 millions of metres, giving a mean for the three determinations of 298 millions of metres. It will be observed that these two agree. June 23rd and June 25th agree so well together that, in all probability, taking off the wooden and putting on a leaden sphere was an unnecessary precaution; 298,000,000 metres represents the mean of 93 discharges of the condenser.

Professor FORBES was very sorry he was not present during the whole reading of this paper. It must have been most interesting to see the exact methods employed by Professor Ayrton, and the manner in which he got over his difficulties. He had only been in time for the result, and he must say it was most intensely interesting to find it so near to the velocity of light, and it was a most interesting confirmation of Professor Clerk Maxwell's computations.

Professor AYRTON said he should have mentioned the way he got over the difficulties of want of perfect trueness of plates. It was extremely difficult in Japan to obtain true plates; a man scraping for weeks could not make them as true as a man in Europe. He levelled the condenser plates at three points, making sets of observations, and he then took three other points and levelled; in fact, taking a large number of sets of three points to find the distance between the plates that gave the same value as if the plates were really planed.

Professor ADAMS said they must all admire the way in which Professor Ayrton had put the matter before them, and the agreement of his results with one another showed very clearly that there must have been immense care taken throughout the whole experiment.

Mr. GORDON said there was one thing he did not understand, the method of measuring electrostatic capacity. Was it done from a calculation of the size?

Professor AYRTON: From the distance between the plates.

Mr. GORDON: Is it not necessary also to know the electromotive force of the battery?

Professor AYRTON: No; perhaps you may remember the method pursued by Professor Fleming Jenkin; he gets a capacity which gives the absolute electromagnetic capacity in terms of a periodic time, sine of half an angle. Of course, the resistance has to be determined with great care.

Mr. GORDON: You mentioned you had to increase the interval between the guard plate and the condenser place. May I ask what guarantee there was that the insulation was quite perfect? I have found in large batteries there was very often a small current. A constant current travels along the surface of the insulator. Unless very great precautions are taken, it would carry away a certain definite portion of the discharge, and it might be exceedingly difficult to detect its existence, but the effect would be to alter the amount of electricity left to be discharged from the galvanometer; and, supposing there was an unnoticed leakage, would its effect be to increase or to diminish the result?

Professor AYRTON: This is a subject to which I have given a very large amount of attention. At one period of the year in Japan it is exceedingly damp, and leakage is a very troublesome thing. The proof that I got over it is this: the method of experiment was to charge certain things and then to discharge them. I charged instantly, and waited a moment before discharging, and I was not satisfied until I could get no difference whatever. In 300 divisions of deflection I would not get one division of difference. In every set I make two or three discharges, waiting a minute.

Mr. GORDON said that was perfectly satisfactory.

The CHAIRMAN said he found in Professor Ayrton all the expectations that were formed in his youth as to his ability, and his anticipation of the

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distinction that would some day await him were amply fulfilled. It would be a benefit to science if they could have him permanently amongst them [applause].

A vote of thanks was then passed to Professor Ayrton for his communication.

The Chairman having to leave, his place was taken by Professor H. J. Smith.

Unilateral Conductivity.

Professor Sylvester Thompson read a paper, prepared by himself and Dr. Lodge, on "Unilateral Conductivity in Tourmaline Crystals." He said: This is rather a formidable title for a very simple though very important phenomenon which I have to bring before the section. I want to connect two phenomena both of which are very obscure, and both of which are most important in respect to the ultimate theory which may be formed as to what electricity really is. These phenomena are those of pyro-electricity and the phenomenon of unilateral conductivity. I am speaking for Dr. Lodge and myself. We began to investigate the matter separately, and have now united our results. In thinking of the possible physical conditions of structure which might permit an explanation of the pyro-electricity of tourmaline and other crystals, it is of use to observe: here is a crystal of tourmaline. If we heat this, while it is growing warm it becomes electrical, one end positively and the other negatively. If, after having heated it, we allow it to cool, it again becomes electrical, but the ends are reversed. At the Glasgow Meeting of the Association in 1876, a paper was read by Dr. Lodge, upon a mechanical model, illustrating the phenomenon of the electric currents. The physical illustrations there given led the way to the suggestion that the phenomenon of pyro-electricity might become explained if it could be shown that such objects as possess pyro-electric properties possessed unilateral conductivity for electricity. Now, what is unilateral conductivity? The name was first employed, I believe, by Dr. Schuster to describe some of the curious phenomena which perplexed him. The term is defined in the following way:—Suppose you, considering a certain direction from a point, A to B, in a substance which will conduct electricity or heat; and if, under any circumstances whatever, we find, on measuring the conductivity of the flow of electricity between A and B, there is a difference in conductivity when we measure from B to A from what there is from A to B, we say that it is unilateral conductivity. There are two very distinct cases in which it may occur. It may occur for sound. Supposing you had a long pipe or tube filled with funnels, all facing the same way down, and you were to speak from one end to the other, the sound would not be conducted equally well up the funnels as down the funnels. The electrical phenomenon which is similar to that exists in certain vacuum tubes. I think it was in Mr. Ladd's shop I saw an apparatus in the form of two parallel tubes terminated at each end in a bulb, both tubes entering the same bulb. In each of these glass tubes there was a series of little funnels of glass; the funnels in one tube joint one way, and in the other tube the other way. When you send the electric spark along it from the lower branch up the funnels, the other branch was perfectly dark; and that is most distinctly a case of unilateral conductivity. Dr. Schuster thought this was due to the loss of conductivity, or defective conductivity at one end or the other. I see in my own opinion some connection between that and the construction of the microphone. It was to be expected that a phenomenon of unequal heating, the analogue of the electric phenomenon, was to be found in the tourmaline. If, when you heat a tourmaline, you have an unequal distribution of electricity, you ought in the same way to have an unequal distribution of heat; it was also to be expected that a pyro-electric crystal, when electrified from without, would have its ends unequally warm. If the developement of opposite electric states at two ends of the crystal were a result of unilateral conductivity, all the analogies of conductors of heat and electricity would point to unilateral conductivity, not of electricity alone, but of heat also. It, therefore, occurred to me, we may put the matter to the proof by an experiment to see if heat was unequally conducted by crystals; and the method that I had recourse to was the well-known method of De St. Arnaud. If you take a thin slice of crystal and cover it with wax, and heat it at the point, if the crystal conducts equally well in all directions, you will have the wax melted in all directions from the centre in a perfect circle. I argued that, if the tourmaline really possessed a unilateral conductivity, we should have the ellipse of melted wax displaced along the axis and have a curve which is not symmetrical about the middle point. We procured a slice of tourmaline, it was roughly circular, and my experiment proved that, when the point of a heated silver wire was introduced into the central hole, the isothermal area presented the form of a distorted ellipse. Two series of measurements were made; and we found that that made with the crystal was covered with double iodide of copper, and mercury gave isothermals of a higher temperature than those produced by wax. The following is a series of measurements made of the semi-minor axes in both directions from the central hole. The average displacement was in the proportion of 100 to 129; the series were 100 to 124, 100 to 142, 100 to 127, 100 to 129, 100 to 124, 100 to 128. These experiments were all made equally while the temperature was rising and before equilibrium had been obtained, and they were made in July, 1877; but, as the experiments had only been made upon one piece of tourmaline, I had very grave doubts as to whether the results might not be contradicted afterwards. Another tourmaline, which I recently obtained from Paris, shows the same thing even better, and the displacement is very clearly shown when this is covered with wax and heated from the point. I find always while the temperature is rising my ellipse is displaced in a particular direction. It then occurred to the authors it would be worth while to measure the flow of heat or electricity across a thin wall of tourmaline. If you take a slice at right angles to the axes out of the middle, and measure the quantity of heat or electricity that flows through the wall, we have a better means of measuring heat and electricity than almost any other. Through the kindness of Professor Maskeline, of the British Museum, we got a slice of black opaque tourmaline from the Oural mountains. Two methods of measurement presented themselves: a small slice of crystal was introduced into the middle of a bar which could be heated, and whose temperature could be taken with thermometers at different lengths; the other limit, which was far simpler, was to make this slice of tourmaline a partition wall between two tubes. I took a glass tube about three-quarters of an inch in diameter, and divided it in two. We had an instrument by which we could send heat from below through the slice of crystal to the tube above; the upper tube was filled with mercury, and a thermometer plunged in it; then steam was blown up to the under surface of the crystal, kept at 100°, and you observed the heat rising in the calorimeter above. After having measured the time required to warm the mercury to a certain number of degrees in this position, the whole instrument was reversed, and the time again taken for the same rise of temperature. The series of experiments gave me this result:—The ratio of the times required to heat the mercury from about 19° to 59°, through 40°, were in the various experiments as 100 to 142, 100 to 141, 100 to 94·5, 100 to 120, 100 to 107, 100 to 118, 100 to 103½, 100 to 119, 100 to 125. There is but one which gives a discordant result. The average of these is 100 to 119. It would, therefore, appear that the ratio of the two conductivities, in opposite directions through the crystals, was as 100 to 119. No great accuracy can be expected in a simple experiment of this kind. It only remains to add that Dr. Lodge has made a few preliminary experiments with a view of testing the unilateral conductivity in tourmalines for electricity. The crystal was heated to the requisite point in a steam bath, a condenser was charged through the crystal from 10 to 12 and then discharged; the conductivity of the tourmaline was so little that the motion of the spot of light was only about two inches on a scale which magnified it considerably. The operation was repeated, having reversed the tourmaline. When the temperature of the tourmaline was rising a distinct difference was observed between the to and fro discharge, and when it was cooled the difference was observed in an opposite direction; with a perfectly steady temperature not the slightest difference could be perceived. We should like to make experiments with a battery of 1,000 cells, and heat the tourmaline to 100°.

Dr. Lodge said he had nothing to add to Professor Thompson's exhaustive communication.

Mr. Preece would like to ask the authors of the paper if they could explain a little more clearly to the section why it was that the question of pyro-electricity would be solved if it could be proved that the conduction of heat in crystals was unilateral. He did not quite see, from what Professor Thompson had explained to them, where the intimate connection was between heat and electricity. Of course, all who were dabbling in electricity and heat were anxious to prove there was an intimate connection between these two forms of activity.

Dr. Lodge said he was very glad Mr. Preece had asked the question. In a paper by Professor William Thomson the molecules of matter were represented as buttons with holes in them, strung on a cord; these buttons were supposed to be vibrating, and, if rougher in one direction than the other, then their harmonic motions will have a tendency to move the cord in one direction rather than the other, and that was what was wanting to explain unilateral conductivity. If you put a piece of rye-grass up your sleeve and you gave a motion, there was just as much tendency to send it up as down, but there was such a great unilateral conductivity that it climbed up [a laugh]. There was a connection between electricity and matter which was not friction, but it was called resistance. Professor S. Thompson was a little more heterodox, for he said electro-motive force was only resistance. That there was a connection between heat and electricity was clear, but why he did not know.

Professor Forbes said, if it was a desirable thing to determine the conductivity during a stationary condition of temperature, it could be done by a method he employed with a good many different substances some time ago. If Professor Thompson would take one of these tubes and fill it with any freezing mixture, with the crystal below it at the end of the tube, and place it in a dish of water until the ice began to form upon it, then remove the ice; the difference of temperature was pretty well established from the difference of the upper surface to the surface on the water; the stationary condition of temperature was arrived at; and, by measuring the time during which the experiment was made and the thickness of the ice on the bottom, you get an absolute measure of the quantity of heat which passes through in a given time.

Mr. Grahame Bell asked Professor Thompson to explain his reference to the microphone.

Professor Thompson said it struck him the essential point of the microphone was also the scientific point of these cases of unilateral conductivity which Dr. Schuster observed, namely, that there should be loss of conductivity. He had a more definite theory on the subject of the microphone than that, but he was hardly prepared to expound it at that moment.

Mr. Preece said he called to mind a rather interesting example of unilateral conductivity. One of their submarine cables broke down from a cause they could not fathom; but they found unworkable currents could be passed through the wire in one direction, whereas no current at all could be passed through the wire in the other direction. It was rather a puzzling problem to solve, but it immediately resolved itself into the fact that there was a loose joint which was in water; the current which passed through decomposed the water and paralysed the joint, and set up an electro-motive force against the current in one direction, and with it in the other [cheers].

The Chairman asked the section to return their thanks to Professor Thompson and to Dr. Lodge for this very important communication [applause].

INDO-EUROPEAN TELEGRAPH COMPANY (LIMITED).

An extraordinary general meeting of this company was held on Friday, the 23rd inst., at the offices of the company, Telegraph-street, Moorgate-street, under the presidency of Colonel James Holland, the chairman of the board of directors, "for the purpose of considering, and, if so determined, approving or adopting, and authorising the carrying out, of a co-operative working agreement between the Indo-European Telegraph Department of Her Majesty's Indian Government, the Eastern Telegraph Company (Limited), and the Indo-European Telegraph Company (Limited), relative to the division between the three administrations of the revenue derived from the transmission of Indian and Trans-Indian messages."

The Chairman, in opening the business, said that the agreement referred to in this circular, and to which they asked the shareholders' consent, was simply a slight modification in the present arrangement. The shareholders had already approved an arrangement, which had now been some time in operation, with the Eastern Telegraph Company. As they were aware, the telegraph line from London to Teheran, in Persia, was the property of this company, and the line beyond, from Teheran to India, was the property of

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Her Majesty's Indian Government. That Government desired to come into the partnership of the company and the Eastern Telegraph Company, and a settlement was required with regard to percentage of profits. Some trifling alterations of percentage in the agreement became necessary, and it was to these that the directors now asked the assent of the shareholders. If all the lines to India were in operation, this would cause a slight falling off in this company's revenue, but in certain circumstances there would be a considerable improvement, and they would have the benefit of Her Majesty's Government being partners in the concern. The concessionary Governments had acquiesced in the agreement, and all that was now required to carry the arrangement into effect was the shareholders' sanction. In conclusion, he moved the following resolution: "That the heads of agreement dated the 28th of May, 1878, between the Indo-European Telegraph Department of Her Majesty's Indian Government, the Eastern Telegraph Company (Limited), and the Indo-European Telegraph Company (Limited), relative to the division between the three administrations of the revenue derived from the transmission of Indian and trans-Indian messages, submitted to this meeting, be and are hereby approved and confirmed, and that the directors be and they are hereby authorised to do all things necessary and proper for carrying out the same, either in its present state or with such alterations or modifications as to the details thereof as they may approve."

The resolution was seconded by Mr. W. H. Barlow, and at once carried unanimously, and the proceedings, which lasted only a few minutes, then terminated.

A Chance for Inventors.—An admirable opportunity for inventors, says the *Scientific American*, is afforded by the necessity of the Government of India, which demands some economical substitute for the wooden telegraph poles that so quickly decay in that climate; and the matter is one of more than ordinary interest, because of the rapid extension of telegraph lines there, and the great probability of their large and immediate increase. Iron telegraph poles have, it is true, been substituted for wooden ones in a number of instances, but neither the cost nor style of them gives satisfaction; what is sought for is a cheap tapering post, light enough for convenient handling, and strong and durable enough to withstand the climatic changes of the country. These conditions are not yet satisfactorily filled by any of the present designs, and it seems evident to us that they can be only by a machine-made post. For a combination of lightness and strength with cheapness, perhaps, nothing could excel a post made of strips of iron wound spirally, and well locked and riveted; we have seen straight pipes made in this manner by machines, both here and in England, but they have not been approved of for the purposes alluded to because of their shape. And in England especially the iron shipbuilding interest seeks for a machine-made tapering iron tube for masts and spars, for the manufacture of them now involves too much hand labour, and consequent expense, to satisfy the builders, and they are ready to welcome the invention that will fill their requisitions. Here, too, the demand would, doubtless, be great enough to well reward the inventor, while the lighter and smaller tapering tubes would meet with ready sale for flagstaffs, fence posts, and numberless other purposes.

TELEGRAPH SHARE LIST.

Amount of Issue.	Amount of Share.	Paid on Share.	Company.	Reserve as per last Report.	Dividends calculated at rate per cent. per annum. 1875. %	1875. %	1876. %	1876. %	1877. %	1877. %	When Payable.	Prices. 1875. Highest.	1875. Lowest.	1876. Highest.	1876. Lowest.	1877. Highest.	1877. Lowest.
£3,254,580	Stock	100	P Anglo-American	Deferred receiving no dividend until 6 per cent. has been paid to Preferred.		year.	5	4†	3	5	† Div. 5 % per ann.* for quarter ending Dec. 31, 1876, 2% for quarter ending Mar. 31, 4 % for quarters ending June 30 and Sept. 30, 6 % for quarter ending Dec. 31, 1877, and 4 % for quarter ending March 31, 1878.	75½	51½	68¾	53	62¼	52
1,872,710	Stock	100	Do. Preferred B		—	—	10	2	6	6		Crtd	1876.	93	75	88½	79
1,872,710	Stock	100	Do. Deferred A		—	—	Nil.	6	Nil.	4		Crtd	1876.	44	29	38	25½
1,300,000	10	All	Brazilian Submarine	120,000	5	5	5	5	5	5	Quarterly.	7¾	6	7¾	5¾	6¾	5⅞
160,000	10	All	Cuba (Limited)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60,000	10	All	Do. 10 per cent. Preference	—	—	—	—	—	—	—	—	—	—	—	—	—	—
116,379	10	9	Direct Spanish (Limited)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
58,430	10	All	Do. 10 per cent. Preference	—	—	—	—	—	—	—	—	—	—	—	—	—	—
65,000	20	All	Direct United States	Nil.	—	Nil.	Nil.	Nil.	Nil.	5	Quarterly.	13	7	11½	6¼	13⅜	9½
369,700	10	All	Eastern (Limited)	110,000	5	year.	5	5	5		*a*Jany., April, *July*, Oct.	8	6⅜	7⅛	5	8¼	6⅝
232,000	100	All	Eastern 6 per cent. Debentures	—	—	—	—	—	—	—	—	—	—	—	—	—	—
200,000	100	All	Do. 5 per cent. Debentures	—	—	—	—	—	—	—	—	—	—	—	—	—	—
700,000	10	All	Do. 6 per cent. Preference	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,997,500	10	All	Eastn. Exten. Australasia & China	125,404	5½	year.	5	year.	5	year.	*a*Jany., *April*, July, Oct.	8¼	7	7½	5⅛	8	6⅞
320,000	100	All	Eastn. Exten. 6 p.c. Deben. (1875)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
192,680	10	All	German Un. Tl. and Tst.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,500,000	10	All	Globe Telegraph and Trust	Nil.	5	7 4–5	4½	7 5–6	3⅜	7 6–7	*b*Jany., April, *July*, Oct.	6¾	5⅛	5⅞	4¼	5¼	4¼
1,500,000	10	All	Do. 6 per cent. Preference		6	6	6	6	6	6	Jany., April, July, Oct.	10½	9¾	10⅛	9¼	10½	9¼
150,000	10	All	Great Northern	85,543	5⅛	year.	6⅜	year.	6⅜	year.	5 % intrm. Jan. 1, July 1. Final Dividend April.	11½	7½	9¾	7	8	7
			Shares to Bearer, or can be Regstrd.														
—	25	All	Indo-European	—	—	—	—	—	—	—	—	—	—	—	—	—	—
120,000	10	All	Mediterranean Extension (Lmtd.)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
32,000	10	All	Do. 8 per cent. Preference	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	18	All	Reuter's (Limited)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
65,000	10	All	West India and Panama	16,000	Nil.	Nil.	Nil.	Nil.	1	1	‡ Converted from a 10 % into a 6 % 1st Preference.	4¾	1⅜	2½	⅝	3⅝	1⅝
34,563	10	All	Do. 6 per cent. Preference		7/6ac	year.	10/ac	year.	6‡	6		12	9	11	7	11	7½
67,500	20	All	Western and Brazilian	7,793	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Half-yearly.	18¼	9½	10⅝	4¼	5¾	4½
$1,500,000	$1000	All	Western Union Telegraph 7 per cent. First Mortgage Bonds	—	7	7	7	7	7	7	May, November.	108	102½	109½	105	113	106
£1,030,000	200	All	Do. 6 per cent. Sterling Bonds	Redeeemable by annual drawings at par.	6	6	6	6	6	6	March 1, September 1.	93	86	98	89	101	94

a Year ends March 31st. Interim Dividend of 5 per cent. Final dividend in July. *b* Year ends July 18th. Final dividend in July.

Companies.	Closing Prices Aug. 28.		Business Done Week Ending Aug. 28. Highest.	Lowest.
Anglo-American	61,	¾	61¾	60¾
Do. Preferred	91,	½	91½	90½
Do. Deferred	34,	½	34½	34
Brazilian	6 13-16,	15-16	6⅞	6¾
Cuba	9½,	10	—	—
Do. Ten per Cent. Preference	16¾,	17¼	—	—
Direct Spanish	1,	½	—	—
Do. Ten per Cent. Preference	9½,	10	—	—
Direct United States	13,	½	13½	13
Eastern	7½,	¾	7¾	7½
Do. Six per Cent. Debenture	106,	108	—	—
Do. Five per Cent. do.	100,	101	101	101
Do. Six per Cent. Preference	11 9-16,	11-16	11½	11½
Eastern Extension	7¼,	½	7 9-16	7 7-16
Do. Six per Cent. Debenture	106,	109	—	—
German Union	8,	½	—	—
Globe Telegraph and Trust	5¼,	½	5½	5 5-16
Do. Six per Cent. Preference	10½,	11	11	10½
Great Northern	8½,	¾	8¾	8½
Indo-European	20½,	21½	—	—
Mediterranean Extension	3,	½	—	—
Do. Eight per Cent. Preference	9½,	10½	—	—
Submarine	228,	233	—	—
Reuter's	10,	11	—	—
West India and Panama	2½,	¾	2½	2½
Do. Six per Cent. Preference	8½,	¾	—	—
Western and Brazilian	4½,	¾	—	—
West. Union 7 p. Cent. 1st Mortgage	114,	118	—	—
Do. Six per Cent. Sterling	102,	104	—	—

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NOTES.

THE BRITISH ASSOCIATION.—The total attendance at the meeting of the British Association was 2,577, and the receipts amounted to £2,605.

THE AUTOMATIC FIRE BELL.—A correspondent of the *Globe* says that the automatic fire bell is by no means a new idea, as above twelve years ago an electrician fitted one up in his warehouse, which was so sensitive that an unusually hot afternoon was found to set it going.

MOSANDRIUM NOT A NEW METAL.—*La Nature* says, on the authority of M. Marignac, with regard to Mosandrium, declared to be a new metal by Dr. Lawrence Smith, that it is nothing else but Terbium, as far as its metallic constituent is concerned, but it does contain an earth, which has already been isolated by M. Delafontaine.

THE INDIAN TELEGRAPHS.—There is some dissatisfaction in India that the office of Director-General of Telegraphs has been kept vacant for about a twelvemonth, thus causing a block of promotion, and keeping the officers of the department in suspense. This delay is supposed to point at an intention to amalgamate the Postal and Telegraphs Departments.

INTERNAL MAGNETISM.—M. J. M. Gaugain, from experiments upon steel tubes and nuclei, concludes that the changes of magnetism which are produced, under the influence of heat, in a solid steel bar, do not differ from those which are produced, under the same influence, in a system composed of a tube and a nucleus. Both seem to depend on the inverse magnetism developed by the mutual reaction of consecutive layers, either of the bar or of the system.

THE RECENT THUNDERSTORMS.—An unusual number of accidents by lighting, both serious and curious, have been reported. At Witham the lightning ran along the telegraph wires into the instruments at the Post Office, fusing the coil of the galvanometer, shooting from thence to the testing box, with a vivid blue flame, succeeded by a loud report, and passing out and along the wires to the Braintree Post Office, seven miles distant, where some slight damage was also done.

EARTH CURRENTS AND ELECTRICAL METEOROLOGY.—Mr. Richard Owen, writing from Indiana State University, Bloomington, Ind., gives an account of some tests with regard to the strength and direction of electrical currents in the earth's crust. He states that when a storm is approaching, the needle of his galvanometer is affected as long as twenty-four or even forty-eight hours before the storm arrives, and suggests that this should be taken advantage of in signal offices. He finds also that, when one wire is attached to earth and the other to a high lightning conductor, the current is from the air to earth, but, with a low conductor, the contrary is the result.

THE RONALD'S CATALOGUE.—The librarian of the Society of Telegraph Engineers has issued a specimen sheet of a catalogue of books and papers on Electricity and Magnetism, compiled by Sir Francis Ronalds, which will be published by that society. The catalogue will contain more that 1,200 entries, including every important work, and almost every paper on Electricity and Magnetism up to the compiler's death in 1873. Its compilation was the labour of a great part of the life of Sir Francis Ronalds, and the library which he acquired during these years is now the property of the society. For the use of librarians a special edition, printed on one side of the paper only, is proposed.

THE MICROPHONE AS A DETECTOR OF MOLECULAR MOTION.—At the recent meeting of the British Association, Mr. W. Chandler-Roberts, F.R.S., read a paper "On the Detection by means of the Microphone of Sounds accompanying the Diffusion of Gases through a thin Septum." The microphone, together with the septum and the apparatus to which it was attached, was surrounded with a jar of hydrogen gas, when a rushing sound was heard, which ceased when the balance was established between the gas and air. Without committing himself to the view that the sounds thus rendered evident by the microphone were wholly due to molecular motion, the author stated several points which appeared to favour this view. Mr. F. Wills suggested that the sound heard might be due to the diffusion taking place in the material (gas coke) of the microphone itself.

SIEUR'S DUPLEX TELEGRAPH.—The duplex system of M Sieur, the apparatus for which is exhibited in the Telegraphic Annexe of the French Exhibition, is shortly to be adopted on the line between Paris and Rouen. It is distinct in principle from all other practical duplex systems, being based upon the use of a "distributor," or automatic current reverser, which divides the time of sending into a series of small and equal intervals, during which a succession of currents, alternately in opposite directions, are sent into the line. These currents are received separately on two polarised relays, corresponding respectively to the direction of the currents. This system equally admits of sending two messages simultaneously in the same direction, or in opposite directions. M. Sieur is said to have invented, also, a system of double and quadruple transmission, based, like the American systems, on the employment of currents of different intensity.

TELEPHONIC.—M. du Moncel has presented to the French Academy, on behalf of M. Righi, professor at Bologna, a new telephonic arrangement, which allows of communications being heard at a distance of several metres from the receiving instrument. The latter is constructed with a parchment membrane, and is similar to that exhibited by Professor Bell at Philadelphia, but has, in lieu of the horseshoe magnet, a straight bar of larger size than that ordinarily used. The transmitter has very much the same form as that with fluid devised by Mr. Elisha Gray, only, instead of water, M. Rhigi employs plumbago powder mixed with that of silver, and the platinum needle is replaced by a disk of brass. The vessel containing the compound powder is held in position by a spring which can be more or less compressed by means of a regulating screw. Two elements of Bunsen constitute the electromotor. When the two instruments are a great distance apart, the secondary wire of an induction coil is introduced into the circuit at each station. The primary wire and the transmitter are traversed by the current from a local battery, or by means of a commutator the receiver may be included in this circuit. It follows from this arrangement that the induced current which passes to the distant station produces its effect only after a second inductive effect upon the primary wire of the local induction coil.

MAGNETIC FIGURES.—A communication from Professor S. P. Thomson appears in *La Nature,* under the title of "Spectres Magnétiques," in which a number of illustrations are given, representing the lines of force in the case of straight conducting wires, in a looped wire, in the case of parallel currents in the same or in opposite directions, &c. These figures are obtained by sprinkling iron filings upon a glass plate, prepared with a solution of gum arabic mixed with gelatine, and placed in the magnetic field of a wire conveying a current. The gelatine being softened by the vapour of

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water, and afterwards dried, the figures become fixed, and may be reproduced by photography or otherwise. In reference to these figures Mr. E. H. Cooke, in the *Chemical News*, says:—"There are probably few who deliver courses of lectures upon electricity and magnetism who have failed to make use of some such simple device for showing the nature of a magnetic field as that now dignified by the term 'magnetic figures illustrating electrodynamic relations.' But the very device used has also been employed. At a lecture upon the 'Telephone' which was delivered at the Bristol Trade and Mining Schools in April last, I exhibited some of these figures upon the screen, and described the method of preparing the plates, which method is *exactly* similar to that now employed by Professor Thomson."

The Electric Light.—We see that an English agriculturist—the Rev. Canon Bagot, rector of Atly—proposes to do his harvesting by the electric light. A correspondent of *Design and Work* says that it is capable of being applied to a bicycle, the only drawback being that, when the machine is at rest, the light is apt to go out. The motor, in this case, is an ordinary magneto-electric machine worked by the hind wheel, and aided by a small pocket battery. The apparatus altogether costs about £5, and the bicyclist asserts that, by its aid, he can see 200 yards ahead on a dark night. Preparations are being made at Woolwich Arsenal for using electricity in illuminating the shell foundry, and for this purpose an apparatus is being fitted up by the Royal Engineers. It is said to be the intention of the Admiralty to have the electric light apparatus fitted on board every sea-going armoured vessel in the Navy as opportunity offers. Messrs. Wilde and Co., of Manchester, have orders to supply several ships with a similar apparatus to that already fitted by them on the *Alexandra*, and two or three others. Commanding officers are unanimously in favour of it, and justly consider the light to be invaluable for discovering and preventing attacks by torpedo boats. Several continental naval powers are also likely to adopt it. As to its use in street lighting, while the Vestry of St. James's are discouraged by the result of their experiment in Pall-mall, the Metropolitan Board of Works, as well as some provincial municipalities, have resolved to consider the question; and, altogether, the gas shareholders are by no means feeling at ease, in spite of the reports of their officials.

The Silk Thread Electroscope.—To the Société des Sciences of Nancy (says the *Scientific American*) M. Rameaux recently introduced a very simple and sensitive electroscope. It consists of a fine fibre of white silk, fixed at one end by means of a little wax to any support, and free to oscillate in any direction under its point of attachment. A single thread would, of course, suffice for the ordinary purposes of electroscopy properly so called, but it is preferable to employ two near each other, taking care to space them so that they cannot foul each other during their swing, or influence each other reciprocally. One of the threads is charged by means of a glass rod with positive electricity. The other is charged by means of a stick of resin with negative electricity. Every body which attracts one of the threads so charged and repels the other is necessarily electrified. Its electricity is of the same sign as that of the thread which it repels. The sensibility of these electroscopes is greater, within certain limits, as the threads are made finer, longer, and less conducting. If the finest sewing silk of commerce be untwisted, each of the parts or strands obtained will make an excellent electroscopic pendulum, which, if about two feet long, is very handy, and suffices for almost all tests. White silk is preferable to coloured. The motions of these threads, if well charged, are considerable, even when the bodies presented to them contain but slight charges of electricity. When the threads are not excessively fine, disturbances of the air do not destroy the observations so much as might be supposed. M. Rameaux has found this arrangement in all cases more sensitive and sure than a carefully constructed gold leaf electroscope which he used for comparison. This system also recommends itself in several ways. For instance: 1. It is so simple that every one can construct and use it. 2. It costs nothing, no special support being necessary. The threads can be fixed to any projecting piece, as the edge of a table, the only condition being that they may hang freely. 3. It can be set up in a moment, and consequently is at once ready for any unexpected requirement; whereas a gold leaf electroscope long unused requires to be dried for hours. 4. It works perfectly, whatever the hygrometric state of the atmosphere. 5. It can be employed to show electric phenomena to a numerous auditory. With long thin fibres and highly electrified bodies, the experiments are very telling.

The Speaking Flame.—Mr. Geo. M. Hopkins contributes to the *Scientific American* an article under this title, in which the apparatus used and the effects produced by him are illustrated by a number of woodcuts. He observes that this flame must not be confounded with the well-known singing flames, as these have but one tone, whereas the speaking flame will produce any note in the scale. The latter is produced by means of a peculiar form of annular burner, similar to those sometimes used in producing the oxyhydrogen light, but provided with an adjustible tip on the end of the outer tube. A mouthpiece is connected with this outer tube by means of a piece of caoutchouc tubing; whilst a second piece of tubing connects the inner tube with the gas supply. The gas being ignited at the aperture of the inner tube, and a flame being placed in proximity to a revolving mirror, like that used with the manometric flame apparatus of König, vocal sounds were produced in the mouthpiece, when the appearance of clear, sharp-cut, characteristic flames, sometimes differing in height, and generally arranged in the form of the teeth of a saw, was observed in the mirror. "In testing this apparatus," says Mr. Hopkins, "I observed that the burner emitted low tones, like those made in the mouthpiece. By carefully adjusting the cup to the outer tube of the burner, I succeeded, without a great deal of trouble, in getting the flame to reproduce distinctly any tone made in the mouthpiece. These tones were evidently produced by the minute and rapid explosions of the gas as it was relit, after being extinguished by the sound waves emerging from the annular orifice of the burner. While sounds can be clearly heard without a resonator of any kind, yet they can be greatly re-enforced by applying a long funnel to the burner. After having nicely adjusted the burner I was greatly surprised to hear the flame reproduce a melody as loudly, clearly, and beautifully as the singing telephone, and with the characteristics of the singer's voice plainly distinguishable; but what was my astonishment when the flame made articulate sounds as words were spoken into the mouthpiece? Scarcely believing my own ears, I placed between the mirror and mouthpiece thirteen feet of rubber tubing, and carried the tube through two walls, so that none of the sounds could possibly be heard from the mouthpiece; still, the flame talked in an intelligible way. . . . The flame has a peculiar appearance when singing or talking; its ghastly blue and its weird sounds are suggestive of the supernatural." Several precautions are necessary in order to produce the best effect.

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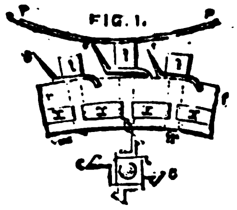
C. GRABNER'S QUADRUPLEX TYPE-PRINTER.

This instrument, which is distinguished by a peculiar contrivance for printing, was patented on December 30, 1875, for Prussia. Here the 60 types *t* (Figs. 2 and 3) of natural size, are disposed in the compass of a type-plate T so as to shift radially; near the type-plate T is a contact-plate C, and both, insulated by a ring *i*, are screwed on to the contact cylinder B. On a special axle above the type-plate is the paper-cylinder P, which is made hollow and as light as possible, and has to take up the paper to be printed in telegraph form. Both ends of the paper are passed through a narrow slit in the convex surface of the paper-cylinder, and are stretched and firmly pressed by means of a wedge. The ground surfaces of the paper cylinder consist of two plates, and their naves enclose, as in matrices, the firmly adjusted axle, a male screw, the height of whose action exceeds

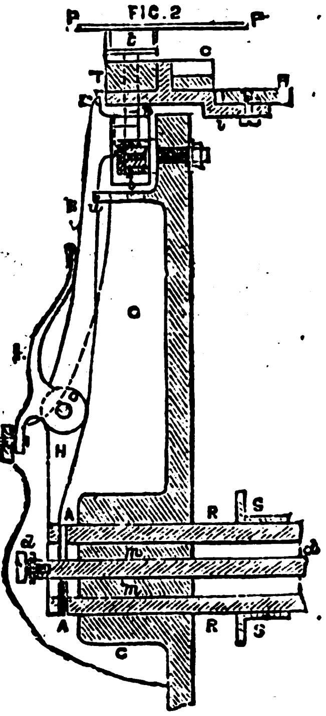
FIG. 1.



that of the types by the interval between the lines. Then, as the cylinder revolves the breadth of a letter with each imprint, the sheet of paper becomes printed like any ordinary printed matter. To the nave of one of the paper-cylinder plates is adjusted a counterpoise to equalise any possible eccentric position of the centre of gravity, and at the same time to regulate the turning after each printing of a letter by firmly bracing the nave to the mandrel. Near the deepest part of the type-plate is an ordinary ink-roller, by which the colouring matter is applied to the types.

The type-plate T, together with contact plate C and contact cylinder, revolves with its axle set in motion by a weight, with the aid of several cog-wheels. But, inside the type-plate T, in the uppermost part of the plummer-block G, is an axle *a*, to which is adjusted a small, light wheel *b*. The four springs *c* attached

FIG. 2



to this wheel lie with their ends within reach of the lower ends *n* of the types *t*; hence, while the type-plate revolves in the direction of the arrow, the wheel *b* is carried along by the ends *n* as long as no obstacle is opposed to its motion. But as soon as the further turning of *b* is prevented, which happens at the indicated place of wheel *b* in fig. 2, the next type *t* with its end *n* is forced up to the spring *c*, whereupon this type is printed off on the paper. With the upward motion of the type the spring *s* curved upwards, and, tapering above, becomes pressed to the paper cylinder P, which it turns round the required piece just before the printing takes place; but, this done, as soon as *n* has passed on over *c*, the spring *s* again presses the type *t* down to its resting position.

The special axle of contact plate B, of the type-plate T and contact-plate C, forms a steel magnet, to the extremity of which is screwed an iron tube R, which is thus continuously magnetised by the steel magnet. The electro-magnetic spool S is further passed over the tube R, one end of the winding connecting with the contact-plate C, the other through the line battery with the earth over the pin *d* lying within tube R, and by *m* insulated from it. The pole at *d* of the battery in question is at the same time connected with one nave of the contact-cylinder B, so that the currents may by the latter be conducted to the line when a telegram is being sent off; but, when a message arrives, the line currents come, on the contrary, from a contact-lever to the contact-plate, and pass to earth through the electro-magnet. But the arriving current is so directed in the electro-magnet S that the tube R, serving as a core and magnetically induced by the steel axle, becomes unmagnetised. Hence, whereas hitherto the tube R retained the ring A (serving as anchor) attracted to the lever H revolving round axle *o*, the powerful spring K, to be correspondingly strained by means of the screw *r*, is now enabled to detach the anchor and place a wedge-shaped adjustment at the upper end of the lever H (acting as a stopper) before a leaf fly of the small wheel *b* and in the arresting place *u*, thus causing the just inverted types to be printed off. When this is completed, the nearest of the cams *x* (see fig. 1) immediately below the type-plate T acts on the upper end of the anchor lever H, and again places the anchor A on the tube-shaped core R.

FIG. 3.

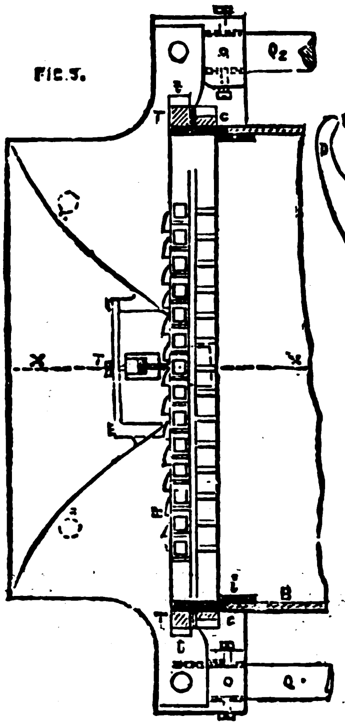
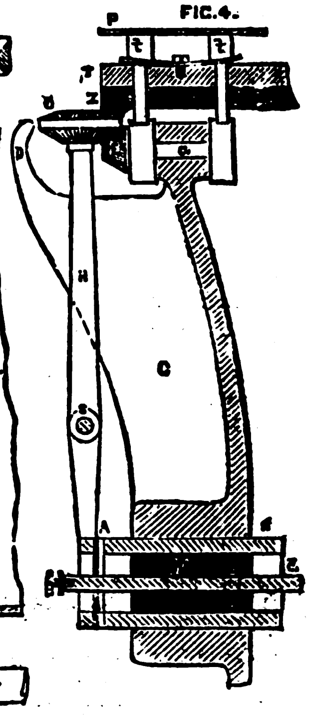


FIG. 4.



In the arrangement of the printing apparatus represented in fig. 4, and differing somewhat from the above, the anchor-lever A, which falls down through the action of the spring at the arrival of the line current, ought to press a double-coned little wheel D into the space between the conic indented flange Z of the type-plate T, and a small conic wheel E adjusted to the shaft *a*, and thereby transfer the motion of the flange to the cam-shaft *a*, whose cones drive the types *t* towards P. Although the teeth of D and E still remain dovetailed together, the double-coned wheel D and the cog-shaft *a* are at once stopped at the recoil of the anchor-lever, because the former with the cylindrical portion between both cones becomes pressed into the arresting place at a firmly-fixed arm *p* of the pillar block G. The types move in the same direction as the cogs. In the first contrivance each type is raised with the fourth of a revolution of the small spring wheel *b*. With a 2 mm. breadth of the type-pin, with a 130 mm. diameter of the pitch-circle of the type-plate, and 1·5 revolution per second, the printing itself will require 1 : ½ (130 × 3·14 × 1·5), that is almost exactly $\frac{1}{300}$ second.

Now, if four such type-printers be connected with a quadruplex telegraph, each of the four contact-plates C, and each of the four contact-cylinders B, must receive 60 contact pins for 60 types. But, instead of arranging each of the four apparatus quite independently one of the other, they are joined together two-and-two in a double apparatus. Then there will not be required four

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contact-cylinders, which would have to be displaced towards each other round every $\frac{1}{4} \times \frac{1}{60} = \frac{1}{240}$ of the pitch-circle in the series of instruments following in succession; but 60 only (instead of 120) contact-pins will suffice for each double instrument with a single contact-cylinder when utilised for both systems of keys of the double apparatus. For this purpose the middle axle of the contact-cylinder B is placed in the middle plane XX (Fig. 3 in ½ *n.* gr.) of the double apparatus, and the 60 metal key-levers of the first type-printer adjusted to the metal axle Q_1 on one side of the middle plane XX, and the 60 keys of the second type-printer to the corresponding axle Q_2 on the other side of the middle plane. The contact-cylinder B further contains the 60 contact-pins corresponding to the 60 types, regularly distributed in a screw-line on the convex surface of the cylinder, and each of which, with the revolution of the cylinder, is touched by the contact-pin on one key of the first type-printer, and by that on one key of the second type-printer, only so far as these keys are pressed down. And since, on the cylinder B, as already stated, one pole is applied to the line battery and the line itself to the axles Q_1 and Q_2, each pressure of a key occasions the transmission of a telegraph current. But, to avoid the confusion of both telegrams arising from the possible simultaneous transmission of currents intended for the 1st and 2nd type-printers respectively, the contact-pins belonging to the second type-printer are displaced by ¼ of the cylinder portion towards the contact-pins of the keys, so that they thus become touched by the contact-pins of the cylinder always by $\frac{1}{4} \times \frac{1}{69} = \frac{1}{240}$ of a revolution of the cylinder later than those of the 1st type-printer.

In the same way the contact-plate C of the 2nd type-printer adjusted to the other end of the axle of the contact-cylinder, and intended for the arrival currents, is, together with its type-wheel, displaced by $\frac{1}{240}$ of the circuit of the cylinder towards the first. On the other hand, the contact levers of all four type-printers acting on the coontact plates C at the arrival lie all together in the same line parallel to the axle XX; hence, after each $\frac{1}{240}$ revolution of the cylinder, another receiver becomes applied to the telegraph conduction. For the rest, these contact-levers are struck back during the transmission, so that they do not then touch the contacts of the contact-plate C.

In the same way that the contact-plate and type-wheel of the 1st and 2nd type-printers are adjusted to both ends of the contact -cylinder of one double instrument, the contact-plate and type-wheel of the 3rd and 4th type-printers are fastened to the contact, cylinder of the other double apparatus, and similarly displaced by $\frac{1}{240}$ circuit of the cylinder towards each other, as is also the case with the contact-pins on the corresponding key-levers. But, at the same time, the contact-plate of the 3rd is likewise displaced by $\frac{1}{240}$ circuit towards that of the first.

The axles of the contact-cylinders of both double instruments lie in the same plane with each other, but are independent one of the other, and are made to revolve by a shorter axle furnished with cog-wheels, the motion from the driving gear being communicated to this short axle itself through wheel-work.

With 60 types and 90 revolutions per minute, each contact lasts $\frac{1}{240 \times 1 \cdot 5} = \frac{1}{360}$ second — the duration of a current, which for the electro-magnet in the Hughes type-printer has been found to suffice on lines up to 500 kilometers long,

For the rest, the Gräbner contrasts so far favourably with the Hughes that it allows letters following each other to be printed off without delay. Hence Gräbner hopes that each type-printer will be able to print at least five signs per second; consequently, all four 20 + 60 = 1200 signs or 240 words per minute. On longer lines and with greater resistance, however, both the number of the types and that of the revolutions might be diminished. At the same time, it should not be forgotten that the performance will be materially reduced through the loss of time occasioned by the rapidly repeated changes of the paper cylinders, unless this be provided against by special appliances, such as have, in fact, already been elsewhere suggested for this very purpose.

To regulate the synchronism, Gräbner has had in view the electric release of the apparatus and an electric correction of the synchronism after each word (by pressing the blank-key); but, on account of the great weight of the revolving masses, he considers a conic pendulum unnecessary. The delay occasioned in the receiver by the pressure would (he thinks) be counterbalanced in the transmitter by the friction of the touched key against the contact-cylinder.

SOME REMARKS ON THE GROUPING OF ELEMENTS IN BATTERIES.

BY DR. ZETZSCHE, OF DRESDEN.

If we arrange n elements in groups of z elements in series, and m in multiple arc, then the current produced by the $n = m\,z$ elements has the intensity

$$(1) \quad . \quad . \quad . \quad T = \frac{\frac{n}{m} E}{\frac{n}{m} \cdot \frac{w}{m} + W},$$

where w indicates the internal resistance of one element, E its electromotive force, and W the external resistance of the circuit. The greatest intensity in grouping is obtained, as is well known, when the total internal resistance equals the external—that is, when

$$(2) \; . \; . \quad \frac{n}{m} \frac{w}{m} = W, \; n = \frac{W}{w} m^2, \; z = \frac{n}{m} = \frac{W}{w} m;$$

and when the maximum intensity of the current obtained has the value

$$(3) \quad . \quad . \quad T_0 = \frac{\frac{n}{m} E}{2\,W} = \frac{E}{2 \frac{w}{m}} = \frac{m\,E}{2\,w}.$$

Thus, with an unchanged internal resistance w of one element, and with the same external resistance W, the intensity T_0 of the maximum current increases proportionally to m; while, on the other hand, the number n of elements to be employed to obtain this intensity increases proportionally to m^2.

If we wish, then, to make a certain intensity of current needed for the object just proposed the maximum intensity, and, moreover, with the smallest possible number of elements n, since each group can contain not less than one element, we must arrange it so that $m = 1$, *i. e.*, in order to satisfy the equation (2) we must choose elements in which

$$(4) \quad . \quad . \quad . \quad . \quad n_0\,w_0 = W;$$

the number of elements necessary will then be, by (3),

$$(5) \quad . \quad . \quad . \quad . \quad n_0 = \frac{2\,W\,T_0}{E},$$

and the resistance w_0 of one element must have the magnitude

$$(6) \quad . \quad . \quad . \quad w_0 = \frac{W}{n_0} = \frac{E}{2\,T_0} = \frac{1}{2\,i_0},$$

where $i_0 = \frac{T_0}{E}$ indicates the ratio of the necessary intensity T_0 to the electromotive force. Here, as in the general formula (3), w appears to depend on the desired intensity T_0, or its ratio i_0 to E. With elements which are not quite constant we might expect to find that w would vary in an equal ratio with E.

If the conditions in (6) cannot be fulfilled, and thus m not be made equal to 1, then, by the general equation (1),

$$(7) \quad . \quad . \quad . \quad n = \frac{T\,W\,m^2}{E\,m - T\,w} = C\,W \text{ elements will be}$$

needed to obtain the intensity T, if we intend to arrange m elements in multiple arc. Then $C = \frac{T\,m^2}{E\,m - T\,w}$.

If now we once more wish to obtain the best results with the fewest possible elements, we must again in (7) put $W = \frac{n\,w}{m^2}$, and we then get

$$(8) \; . \quad . \quad n = \frac{T_0\,n\,w}{E\,m - T_0\,w}, \text{ or } E\,m = 2\,T_0\,w, \text{ and}$$

$$(9) \; . \quad . \quad . \quad . \quad m = \frac{2\,T_0\,w}{E} = \frac{w}{w_0},$$

and as the total number of the now necessary elements;

$$(10) \quad . \quad n = \frac{W\,m^2}{w} = \frac{4\,w\,W\,T_0^2}{E^2} = \frac{2\,T_0\,w}{E}\,\frac{2\,T_0\,W}{E} = m\,n_0.$$

If m comes out from (9) as a mixed number, we must choose of the two nearest whole numbers the one for which n in (7) comes out least.

Since, under the relations just set forth, w is less than w_0, if formula (9) produces for m a value less than 1. For instance, $m = 1 : x$, where x is now greater than 1, nothing remains but to arrange the elements singly one behind the other. In order to obtain the intensity $T_1 = \frac{n_1\,E}{n_1\,w + W}$, we need not only $n = \frac{W\,m^2}{w} = \frac{W}{w\,x^2}$ (cf. (2)), but also by (7)

$$(11) \; . \quad n_1 = \frac{T_1\,W}{E - T_1\,w} = \frac{W}{w}\,\frac{1}{E : T_1\,w - 1} = \frac{n\,x^2}{E : T_1\,w - 1}$$

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elements must be employed. Here T_1 must have the same magnitude as T_0, and, therefore, by (9) we may put

$$E : T_1 w = E : T_0 w = 2 : m = 2x;$$

and then

$$(12) \quad . \quad . \quad . \quad n_1 = \frac{n x^2}{2x - 1} < n x^2,$$

and, moreover,

$$(13) \quad . \quad . \quad . \quad n_1 w < n x^2 w = W.$$

Further, $x + 1 > 2$, and consequently $(x + 1)(x - 1) > 2(x - 1)$, or $(x^2 - 1) > (2x - 2)$; thus $x^2 > 2x - 1$, and consequently $n_1 > n$. Thus we obtain from the greater number of elements ($n_1 > n$), notwithstanding the decrease in the resistance of the whole battery ($n_1 w < W$), only the intensity $T_1 = T_0$, because the elements do not produce the maximum current.

If we were, however, to make use of a resistance x times as great ($w_0 = x w$), then by (9) m_0 would equal

$$\frac{2 T_0 w_0}{E} = \frac{2 T_0 w x}{E} = m x = 1,$$

and the elements would now, moreover, produce the maximum intensity of current; but yet their actual total number, n_0, is greater than n_1, because the resistance of the battery has increased to

$$(14) \quad . \quad . \quad . \quad . \quad n_0 w_0 > n_1 w.$$

By (4) and (5) we find likewise

$$(15) \quad n_0 = \frac{2 W T_0}{E} = \frac{W}{w_0} = \frac{W}{x w} = n x = \frac{n_1 (2x - 1)}{x}$$

$$= n_1 \left(2 - \frac{1}{x}\right) > n_1,$$

and therefore the actual resistance of the battery is

$$(16) \quad . \quad n_0 w_0 = n w x^2 = n_1 w (2x - 1) > n_1 w,$$

i. e., greater than it was before, when the elements of resistance were arranged singly.

From (16), lastly, we get $n_1 = \frac{n_0 x}{2x - 1} = \frac{n_0}{2 - \frac{1}{x}}$, and we thus perceive, in accordance with (11), that n_1 decreases in proportion as x increases or w decreases.

August, 1878.

GOVERNMENT SCHOOLS OF TELEGRAPHY.

In a recent number we announced that the French Government had instituted a School specially devoted to the study of Telegraphy; and we purpose giving in due course some account of the system of instruction pursued in that establishment. Meanwhile it is gratifying to find that the Government service of this country has begun to make some progress in systematic instruction in Telegraphy—not merely as an operative art, but as a scientific profession. Gradually the conviction has forced itself upon the authorities of the Post Office that perfect efficiency in telegraphic administration will finally depend upon the mastery its employés acquire over the principles of the apparatus they are called upon to use. Telegraph Schools at the chief centres of activity, for some years past, have, with more or less completeness, been laying the foundation of sound electrical knowledge among the operators; and, as the additions to the force have been enormous since the acquisition of the telegraphs by the Government, the effect upon the service generally is already beginning to be felt.

More than this, however, if the answers to Parliamentary questions may be trusted, the Post Office is insisting upon a knowledge of Telegraphy as an indispensable acquirement for those who seek superior postal appointments. The happiest results may be anticipated from this regulation; for it will tend to weld the two services together, and will bring to the telegraph section that higher intelligence which, without invidiousness, we may assume to be possessed by those who are to be its future controllers.

Of course, a similar regulation prevails in respect to the promotion of operators and supervisors; and it is obvious that very little artificial encouragement is needed where self-interest is so directly appealed to. But facilities of the most liberal kind are afforded by the Government, so that there can be no excuse for failure in satisfying its conditions. A large and fully equipped school exists in the metropolis, to which the majority of the aspirants gravitate; and there are similar establishments for Ireland and Scotland. But, to meet the wants of those who cannot be absent from local duties, experienced instructors traverse the provinces and afford personal teaching wherever it is needed; and we understand that a considerable body of postal officers, especially such as are visiting inspectors, are absolutely required to undergo this kind of tuition, the ultimate aim apparently being to render the offices self-maintaining by making the postal officers practical electricians.

The scope of the technical instruction varies, as might be expected, with the age and status of the pupil. For boys, who are admitted as learners as young as fourteen and not older than eighteen, it is of necessity quite elementary. In this respect the conditions differ from those prevailing with private cable Companies, who may exact, because they can obtain, higher technical attainments in the older candidates whom the exigencies of foreign travel compel the companies to employ. In the Postal Service, on the other hand, the practical advantage of training the hand while it is yet flexible and dexterous outweigh all other considerations; and, as there are a great number of instruments to be learnt—nowhere so multiform as in this country—the learner's time is thus almost fully occupied during his three months' stay in the schools. Oral instruction, accompanied by simple experiments, is, however, given to these pupils collectively; and they are taught the more familiar properties of electricity as applied to the purposes of the instruments they are learning to work. Thus, at the very outset of his career, technical knowledge is made to form part of the accomplishments of the future telegraphist. With examples for study constantly before his eyes, and a pecuniary incentive to use them aright, there is, therefore, little fear that he will long remain what the chairman of a Parliamentary Committee once described him, an ambidextrous monkey.

Instruction of a higher order and of wider range is provided for the established officers of the department. Courses of lectures are given by its electricians, and ample directions and assistance are given for persevering personal study, so that all must learn something, and many will become accomplished. A certain degree of manipulative skill is required of this class of pupil also, and, we think, very wisely, for no superintending officer can efficiently discharge his duties without knowing something—the more the better—of the difficulties, the excellencies, and the possibilities of actual work. A sufficiently searching examination from time to time appears to form part of this scheme, but the details are not known outside official circles.

On the whole, the primary aim of these English schools, so far as we can ascertain, is to impart useful practical knowledge, not to the exclusion of, but certainly in preference to, the theoretical and scientific branch of the subject. We think it very desirable that this branch should receive greater attention on the part of the Post Office authorities than has hitherto been devoted to it; but, until the organisation is more thoroughly unified, there will, no doubt, be some difficulty in extending the tuition in this direction. Whether the French administration, which has had a much longer Governmental existence than that of this country, claims to do more than is done by our officials is a point upon which we hope presently to be able to inform our readers.

STUDENTS' COLUMN.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to "L. A. D.'s" query, I think if he tries the following plan he will find that he can decompose water very rapidly with one Wollaston cell. He must arrange, in the circuit of the battery, an electromagnet (consisting of a bar of soft iron with a helix of wire wound round it), and in front of one end of the soft iron must be a vibrating spring, with soft iron hammer, which has a platinum nipple striking on a platinum-pointed screw. The voltameter is placed, one side in connection with the nipple, and the other in connection with the screw. The battery is placed one pole to one end of wire on electro-magnet, the other to the platinum screw, so that, supposing the spring to be held back, the battery current flows through the coil and spring back to the battery; but, in reality, the spring is instantly attracted, and the *extra current*, as it is called, which occurs on breaking the circuit, passes through the battery coil, and this time through the voltameter. This current is a great deal stronger than the battery current, and, as the spring makes and breaks contact eight or ten times a second, the *extra current* is, so to speak, almost a continuous current, and the water is decomposed very rapidly, from ten to twenty cubic centimetres per minute being sometimes evolved.

This arrangement is ascribed to M. Daguin, a French electrician.—I am, &c., ALFRED C. M. WEAVER.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

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All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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Quarterly	4s. 10d.
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NOTICE TO EDITORS.

We shall be happy to exchange with the Editors of Scientific journals who receive the first numbers of THE ELECTRICIAN.

Nous serons heureux de faire l'échange avec Messieurs les Rédacteurs des Journaux scientifiques qui recevront les premiers numéros de L'ELECTRICIAN.

Es wird uns ein Vergnügen sein mit den löblichen Redactionen der deutschen und anderen continentalen Journäle und Zeitschriften, denen die ersten Nos. des ELECTRICIAN *zu Händen kommen möchten auszutauschen.*

I Signori Editori di giornali scientifici che riceveranno i primi numeri dell' ELECTRICIAN *ci faranno cosa gradita accettando il cambio che loro offriamo.*

PROTECTION AGAINST LIGHTNING.

This year has been remarkable, on both sides of the Atlantic, for the number and severity of its thunder storms. The neighbourhood of London has especially suffered. Looking back on the summer, it seems to us as if every Sunday had brought an impressive sermon of this kind, which, if it taught no other lesson, was at least a warning to those Sabbath breakers who, in their best clothes, had exposed themselves on Hampstead Heath or Clapham Common. Now, that, after such an oppressive August, we breathe freely, attention may be appropriately called to a paper read by Mr. Anderson to the British Association, on accidents by lightning and the means of guarding against them.

Mr. Anderson's statements are by no means assuring. Many of us, when caught in a thunderstorm, have been accustomed to take refuge, first, it may be hoped, in a good conscience, and then in statistics, which, without ever having looked very closely into them, we felt sure would be in our favour. When the bolts were flashing around, we have kept telling ourselves that, if the truth were known, we were, after all, safer than in crossing Regent Circus on a busy afternoon, or in travelling by express train from Holborn to Ramsgate. But Mr. Anderson informs us that, from 1869 to 1876, the deaths from lightning in England and Wales are recorded as 182; and this estimate he takes to be very much under the mark, since, during the same period, 819 deaths from lightning are reported in Prussia, where, with a population very slightly larger, there are fewer thunderstorms and a more complete system of registration. Surely, he must be mistaken in his supposition that over a hundred people are killed every year by lightning in this country. In America the ordinary number is from fifteen to twenty, if we may rely upon an electrical contemporary. We should be glad to receive further information on this point. Such information ought to be attainable, and would certainly be useful in teaching sensible people what they really had to fear from thunderstorms, though no amount of statistics would lessen the dread with which ignorant and nervous people behold these manifestations of the powers of nature. In the meanwhile, we are inclined to think that, in our climate, fewer lives are lost by the stroke of lightning than by being wet through in a storm, and that the danger to property, year by year, is not so great as that arising from the more frequent and less terrific phenomenon of a child playing with matches. So, if any of our readers should be unavoidably exposed to the rage of the elements, we advise them to keep a good heart, to think of the drains, the Corporation dinners, the metropolitan water companies, and all the more fatal weapons of death through which we are daily and hourly running the gauntlet, and, above all, not to place their bodies in any position likely to become the line of least resistance for the electric discharge.

Though we cannot accept Mr. Anderson's estimate of accidents from lightning, we are at one with him when he dwells on the want of reasonable precaution which is just in proportion to our unreasonable dread. Forty years after Franklin's celebrated discovery, his biographer observed with surprise how backward we in England were to avail ourselves of it; and now Mr. Anderson brings forward facts to show what astonishing carelessness, to give it no worse name, still prevails among us about the proper use of lightning conductors. Not only are a very small proportion of private houses provided with them, but he tells us this simple precaution is not applied to at least one-half, and probably two-thirds of our public buildings, including some of those magnificent cathedrals whose loss would be irreparable. Windsor Castle itself, he declares, from his own observation, to be insufficiently protected. It cannot be too widely known that a lightning rod is not to be relied upon as protecting more than an area extending twice its own height. At Windsor Mr. Anderson, on a recent visit, found no conductor on St. George's Chapel, or on the adjoining belfry tower; while, as for the rods that stand over the Queen's private apartments, he is very sceptical as to whether they "actually have their root in moist earth." Here is another danger of which the general public is almost entirely unaware. A man puts up a lightning rod, and for the rest of his lifetime fancies himself safe beneath its slender shadow, though, for many years, it may not have been tested, and may have originally been erected without any scientific knowledge being called into counsel. But, unless his conductor is complete, with a good connection with perfect earth, it may be actually worse than useless, since it only acts by becoming part of the cloud, so to speak, and gives off lateral charges during the impeded passage of the electricity, with results that may be imagined, and are described by Mr. Anderson in one instance as "lifting up heavy marble toilet tables in bed rooms some six feet distant on either side of the copper rope, which, under other circumstances, would have carried the electric force noiselessly as well as harmlessly to the ground."

Such a danger could have been foreseen by a scientific electrician; but it is to be feared that many lightning-conductors are no more efficient. Suppose that a conductor ends in dry shallow earth, embedded in chalk, it is only inviting the lightning to pass with difficulty and disturbance along the premises thus insecurely guarded. Good earth,

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in the electrician's sense, is not to be had so easily as that which a gardener would approve of. It is always safe if your conductor leads into a stream or well, where the electricity will be at once conducted away. If this be out of the question, it is well to bury a few sacks of coke in moist earth, and let the end of the rod terminate among the coke, rivetted to a large fragment of gas carbon or graphite, carefully providing against oxidisation by insulating the rivetted joint, preferably with paraffin wax; this contact will last a century. To make sure, the conductor may be tested with a galvanometer connected with "dead" earth elsewhere; if, then, the resistance be found to be merely the resistance of the wire, you may consider you have a real protector so long as the apparatus remains intact.

All owners of property should follow Mr. Anderson's strong recommendation, that competent persons be employed not only to erect but periodically to test lightning conductors at every point where they may be required. In Paris, he says, and other French towns, there exists a regular system of inspection and testing. Those who have the charge of our public buildings should lose no time in looking to this matter. The season of thunderstorms is not yet over, and as things stand now, the Bishop of Peterborough, sitting on his episcopal throne, may any Sunday become the vehicle of an electrical discharge, struggling like a giant to reach its native earth by way of the verger's mace. We wish his lordship no harm; yet we cannot but recall Sydney Smith's celebrated dictum on the most effectual way of calling attention to a neglected danger.

THE PARIS EXHIBITION.

For some time after the opening ceremony the Exhibition was in a very incomplete state, but now every corner is filled, and in many cases inconveniently so. The electrical apparatus, unfortunately, is scattered over various portions of the buildings, and, except in the French Department, there can hardly be said to be a fairly good representation of any country. It would be far more advantageous to the electrical student if all the apparatus could have been placed in one annexe, for then comparisons could easily have been made. There are a few instruments at Paris which deserve careful attention, and show the progress that has been made since the last "World's Fair." We were particularly fortunate in seeing the electrical apparatus at the Exhibition, inasmuch as M. du Moncel was kind enough to point out the position of the most interesting specimens, and to give us a clear and lucid description of the instruments. We are sorry that we cannot reproduce M. du Moncel's words, for then our readers would have had a far better exposition of the contents of the Exhibition relating to this subject than we can hope to give. Before entering upon the subject proper of these papers, we would refer to our experience in another direction. Our visit to Paris was during the meeting of the French Association for the Advancement of Science, and, as members of that society, we received an invitation from the Société Française de Physique to a *soirée scientifique* at the Conservatoire des Arts et Métiers. The science at this soirée was, to a great extent, electrical. The quadrangle or garden was illuminated with the electric light, as were also the grand staircase and the machine-room. In the last, the shadows, except between the two lights used, were too intense to allow any workman to work in comfort, but between the lights the effect was not so bad, whilst it was perfectly obvious that the same amount of light radiated from four centres instead of two would have given far better results than gas. In the garden, the most delicate shades of the flowers could be as easily distinguished as in daylight, and we were more than ever convinced that the electric light was destined to be the light of the future. Improvements in producing it economically, in dividing the light, are continually made, as will be seen in the course of these papers. In the library, M. Breguet showed a Gramme machine, besides a variety of apparatus. The rooms containing the phonograph and telephone were, as usual, centres of attraction. One of the most interesting machines to us was an electro magnetic graveur at work, shown by MM. Christofle et Cie. The design to be reproduced is inlaid in brass on a cylinder with a circumference equal in length to the tray or other object upon which it is desired to place the design. The machine is really a modification of Caselli's automatic telegraph. The remaining portion of the cylinder is made of bad conducting material, and, as the contact piece passes over the conductor, the current is short circuited, but, when the contact piece passes over the bad conductor, the current passes to the coils of an electro-magnet which acts upon the graving tool. When, therefore, the contact piece passes over that part of the cylinder containing the design to be reproduced, the graving tool is prevented from cutting, and ultimately the design stands out in relief on the object in the hands of the workman. Gramme machines are being used for the electric light, and also for the deposition of metals. This seems to be an example it would be well for us to follow. Some years ago an effort was made to establish at South Kensington something similar to the "Conservatoire des Arts et Métiers," but the instruments were put under glass cases, and the value of the display to students was incomparably small. In Paris the machines work, and thus students derive full benefit from the time spent in examining the machines.

[TO BE CONTINUED.]

GENERAL CONSIDERATIONS UPON TELEGRAPHIC TARIFFS.*

[CONTINUED FROM P. 171.]

7. *Should the tariff be proportionate to the net cost?*

The proportion of charges to net cost may be considered from different points of view.

A. *According to distance.*—Within the same country and also within the limits of the terrestrial telegraphic system of central Europe distance exercises but little influence upon the net cost of the correspondence, the cost of labour and instruments outweighing the expenses of interest and maintenance belonging to the conducting wires strictly so called. But if we take account of the value of the service rendered for the consumer, that is to say for the correspondent, it is necessary to recognise that this value increases with the distance—if not proportionately to the distance. The value of the telegram consists, in fact, in the time it gains over the ordinary courier.

Beyond the limits of territory where the facility of appreciation it gives to the public is the motive for uniformity of tariff, it is rational and legitimate to raise the charge not in the ratio of the distance, but to a point between the increase of the distance and that of the net cost.

B. *According to speed.*—A telegram delivered to the receiver a quarter of an hour after being handed in, in virtue of a priority acquired by means of a higher charge, costs no more to an administration than if it had been delayed two or three hours. Nevertheless, this speed can, under certain circumstances, constitute a service rendered of the highest importance, irrespective of the net cost.

C. *According to the nature of the correspondence and the guarantees which it requires.*

Experience shows us that the ordinary conditions and chances of the service suffice for the correspondents of the majority of private telegrams.

It is the same with these telegrams as with almost the whole of the postal communications. One knows that for both the administration has organised a system of minute, but not infallible precautions; that a letter mislaid, a telegram delayed, not delivered, or mutilated, constitutes a rare exception, but an exception to be expected. Those who wish guarantees demand for a telegram urgency, registration, receipt, repetition, or acknowledgment of receipt; these operations augment the value of a telegram, but they also increase the net cost, and it is reasonable to impose a surcharge proportionately higher than the extra expense entailed upon the administration.

We have seen, in fact (questions 5 and 6), that the telegraph should demand from the public a total fixed remuneration. It can obtain this in two ways—either by charging on all messages, without distinction, an equal tax, or going to extreme limits of cheapness for ordinary telegrams and obtaining a compensation upon exceptional operations. The latter method is incontestably more liberal and better calculated to increase the correspondence.

D. *According to the destination of the messages or the category of the relations.*—It is notorious that an internal telegram, necessitating on the part of the administration of a country two series of operations at least, despatch and receipt, costs more to an administration than a message exchanged with abroad. Never-

* Translated from the *Journal Télégraphique.*

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theless, in most of the countries of Europe, the tax of an international telegram is higher than the internal charge.

Is this an evil? Evidently not.

Cheapness in the interior is more important than cheapness for foreign traffic would be, not only because the number of messages is greater, but also because the distance is less (see section above), and the circumstances in which one corresponds with abroad, generally justify a greater expense on the part of the sender, which, however, does not restrict in the same degree the development of the traffic.

It is wrong to impute to countries which have established this apparent anomaly the idea and fact of benefiting their people at the expense of foreign countries.

In uttering this opinion, it is forgotten that the international taxes are paid by the *inhabitants* of all the countries.

It is very true that, if a Belgian or a Swiss can correspond in his own country for half a franc, it is partly because that country taxes international or transit telegrams at a franc. But this Belgian or Swiss also pays this tax of a franc; he pays, in addition, the same tax in the other countries of equal extent, and a double or triple part in the great countries. He is not then more benefited than the others.

It is true that the reproach has been pushed further. It is said that small countries pay for the great the cost of their interior telegraphy. In order to show that this idea had the least foundation, it would be necessary to prove that an international or transit telegram costs two or three times as much to a large country as to a small one. Thus it is a question of net cost, which it would be necessary to solve first of all.

The international tariff is, or ought to be, established according to the principles of reciprocity which make it an equal charge to the people of all countries. The offices concerned having obtained their equitable and proportionate part in the benefits of this tariff can at their pleasure make the internal telegrams to profit more or less without foreigners being injured.

From four points of view which are about to be examined, these taxes are not and ought not to be proportionate to the net cost. This fact does not occur in telegraphic correspondence only.

Not to speak of trade, where the question of net cost is ruled by the law of supply and demand, we find in the post letters carried without profit, and printed matter at a loss; on the railway passengers conveyed at a profit, while goods, in part, at least, are transported either at a loss, or at a very small profit. These differences ought to be evident. A charge of 10c. per letter for Belgium, of 25c. for all Europe cannot restrain the growth of the correspondence. The resultant profit makes it possible to grant to newspapers and books a rate of one centime for Belgium, of five centimes for the rest of the postal union, without which these would not have obtained their enormous circulation, and the benefit which has resulted for publicity, commerce, &c., would not have been obtained.

Similarly, a railway enterprise which desired, while covering its expenses, to favour industry and commerce, might find itself, in case of lowering the charges for certain classes of merchandise below the net cost, retrieving the loss by the receipts from passengers, provided that the tariff imposed on the latter was not so high as to retard the increase of journeys.

E. *According to the Division of the Taxes amongst the Offices concerned*—The total tax between two points being assumed according to the established rules, and supposing that several offices have taken part in the transmission, what plan of division is it advisable to adopt?

Here the net cost seems to be the principal element for appreciation. If one sought the means of rectifying the bases of actual division, it would be necessary to apply a calculation similar to that which is reproduced in the first part of this work to each office, and to complete it by adding to the annual expense (which we have alone considered) the interest on the respective capitals engaged in the part of the system devoted to the international telegraphy. It would, evidently, be necessary to subtract the expenses which each state appropriates, according to its own convenience, to the requirements of its internal correspondence, official or private. One could not take into account the difference of expense which is caused by a more or less economical management.

The researches of each country ought then to be submitted to a general revision, in which average and uniform formulas should be applied to the same units of work and expense.

We believe there has been in fact, if not in principle, a tendency to a uniform mode of division on the successive revisions of European international tariff. Charges have never been proportionate to distance.

The Convention of the 16th May, 1850, between Belgium and Russia—which is, we believe, the oldest international telegraphic convention—observed, in Art. 10, the principle of reduction of charge per unit of distance, in direct ratio of the extent of line to be traversed. The first application of it was made by uniting the two internal tariffs, *i.e.*, in Belgium, three zones, less than 75 kilometres, from 75 to 200 kilometres, and above 200 kilometres; in Russia, increasing zones of 10, 15, 20 miles, &c. The following year France adopted the same idea for her interior tariff by means of a fixed charge of three francs, to which twelve centimes per myriametre was added.

The system of increasing zones, which contined until 1865, gave two or three proportions to small territories, six or seven to the large. The average was 1½ proportions for the one and 3 for the other. The arrangements between neighbouring states previous to the Convention of Paris (1865), and which are maintained until the present time, were concluded by mutual accord, upon the basis of one franc for small countries, and two francs for large states. The latter, it is true, obtained three francs as terminal and *general* transit-tax in the tariffs of 1865; but the exceptions to two francs have been maintained, and are even increased. We believe that they ought to become the rule, and that a division in connection with the respective net costs would not give to large territories even twice as much as to small states.

8. *Is absolute uniformity of tariff a benefit by itself? To what limits should it be extended?*

We do not treat here of the uniformity of conditions granted to every correspondent, whoever he may be, nor of uniformity of arrangements concerning regulations.

The first is by right, the second is essential for facilitating and simplifying the relations of the administrations between themselves and with the public.

The question relates to a uniform charge, whatever may be the distance, whatever the degree of urgency or importance which the sender attaches to the telegram he wishes to forward.

This absolute general uniformity has its devotees, not to say fanatics. Certainly, it is convenient not to have to concern oneself about a fixed radius, to consult a variable table for each starting point in the same country. But does this facility compensate for the inconvenience of a higher relative charge upon short distances, where for the consumer the value of the telegram is least, because it gains least on the post? Either the uniform tariff is reduced to a ruinous point for the working, or, if remunerative, it is too dear for short distances.

In England, where the purchase of the private undertakings was effected on the demand for a uniform, and reduced charge, public opinion has willingly sacrificed the 6d. rate, which had formerly been applied within the limits of the large cities, and of certain districts, in order to obtain all communications, without exception, for 1s. It is true that the public considered this rate temporary, and reckoned upon seeing it reduced to sixpence for the three kingdoms. The experience of six years has dissipated these illusions, and the uniform tax of one shilling presents at once the two following unpleasant alternatives. It is not remunerative, and the charge of 6d. for a short distance is rescinded. In a long article on the report already mentioned of the Treasury Committee upon this grave position, *The Times* of 13th Sept., 1875, after having reviewed the recommendations of the committee, expresses itself in these terms:—"While entirely approving the principle of uniformity, we believe that there are within well defined limits circumstances in which one might depart from it with advantage for the public and profit for the revenue;* we mean by that the introduction of a system of local telegrams in London, in the other large towns, and in certain districts, at a uniform† tax of 6d."

In France the adoption of a uniform charge of two francs reduced to one franc, then raised to francs 1·40, has left at a lower charge the circumscribed relations within the same department.

In Germany, where there were three zones taxed respectively at 50, 100, and 150 pfennig for 20 words, the tariff has been made uniform with an increase per word from 1st March, 1876.

We understand the unique and uniform tax in Belgium, Holland, Switzerland, &c. But when it is applied to larger territories it seems to us that the rate considered remunerative for the whole, and which represents to correspondents twenty or thirty hours gained upon the ordinary post, is too high a charge for telegraphing from Paris to Versailles, or from Cologne to Aix-la-Chapelle.

In 1865, the Paris Conference examined the proposition for taxing at four francs per twenty words all telegrams exchanged in Europe without distinction ‡. This combination, eminently

* Always the same hope, which the facts have never confirmed.

† Why "uniform"? Is it to cover by the word the abandonment of the principle?

‡ This is a slight error of memory. It was not the sum of four but of six francs which was put forward at Paris in 1865 as a uniform tax for Europe. It was at Rome, in 1871-2, that the sum of four francs was mentioned in a proposition of a similar nature, withdrawn, however, before discussion by the delegate of the office (Roumania) from which it emanated.—(Note of the *International Bureau*.)

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advantageous for correspondence from Lisbon to St. Petersburg, or from Dublin to Constantinople, still would not increase these messages much where the telegraphing community is not numerous. It would, however, sensibly diminish the traffic between adjoining or near states to the detriment of the numerous relations between these countries. This grave inconvenience would involve without doubt the maintenance of the reduced taxes already applied between them, and then the system, while ceasing to be uniform, would become ruinous for great distances without compensation in the nearer relations. One understands, then, why this proposition was discarded for a long time to come.

A higher tax is justified beyond a certain distance by the single fact that the telegram has a much higher value for correspondents. It is equally justified when greater promptitude (priority of transmission) or other special advantages are obtained.

These higher charges constitute the only means of preserving a reduced tariff for short distances, and for ordinary correspondence.

[TO BE CONTINUED.]

NOTE ON THE THEORY OF ELECTRIC ABSORPTION.

BY H. A. ROWLAND, C.E.

In experimenting with Leyden jars, telegraph cables, and condensers of other forms in which there is a solid dielectric, we observe that, after complete discharge, a portion of the charge reappears, and forms what is known as the residual charge. This has generally been explained by supposing that a portion of the charge was conducted below the surface of the dielectric, and that this was afterwards conducted back again to its former position. But, from the ordinary mathematical theory of the subject, no such consequence can be deduced, and we must conclude that this explanation is false. Maxwell, in his "Treatise on Electricy and Magnetism," Vol. 2, Chap. X., has shown that a substance composed of layers of different substances can have this property. But the theory of the whole subject does not yet seem to have been given.

Indeed, the general theory would involve us in very complicated mathematics, and our equations would have to apply to non-homogeneous crystalline bodies, in which Ohm's law was departed from, and the specific inductive capacity was not constant. We should, moreover, have to take account of thermo-electric currents, electrolysis, and electro-magnetic induction. Hence, in this paper I do not propose to do more than to slightly extend the subject beyond its present state, and to give the general method of still further extending it.

Let us at first, then, take the case of an isotropic body in general, in which thermo-electric currents and electrolysis do not exist, and in which the changes of currents are so slow that we can omit electro-magnetic induction. The equations then become*

$$\frac{d}{dx}\left(\kappa\frac{dV}{dx}\right)+\frac{d}{dy}\left(\kappa\frac{dV}{dy}\right)+\frac{d}{dz}\left(\kappa\frac{dV}{dz}\right)+4\pi\rho=0,$$

$$\frac{d}{dx}\left(k\frac{dV}{dx}\right)+\frac{d}{dy}\left(k\frac{dV}{dy}\right)+\frac{d}{dz}\left(k\frac{dV}{dz}\right)-\frac{d\rho}{dt}=0,$$

in which κ is the specific inductive capacity of the substance, K the electric conductivity, V the potential, ρ the volume density of the electricity, and t the time. The subtraction of one equation from the other gives

$$(1)\quad \frac{dV}{dx}\frac{d}{dx}\left(\log\frac{k}{\kappa}\right)+\frac{dV}{dy}\frac{d}{dy}\left(\log\frac{k}{\kappa}\right)+\frac{dV}{dz}\frac{d}{dz}\left(\log\frac{k}{\kappa}\right)-\frac{1}{k}\frac{d\rho}{dt}-\frac{4\pi\rho}{\kappa}=0.$$

To introduce the condition that there shall be no electric absorption, we must observe that, when that phenomenon exists, a charge of electricity appears at a point where there was no charge before; in other words, the relative distribution has been changed. Hence, if the relative distribution remains the same, no electric absorption can take place. Our condition is then $\frac{\rho}{\rho'}=c$, where c is independent of t, and ρ and ρ' are the densities at the points x, y, z, and x', y', z'. This gives $\frac{d}{dt}\left(\log\frac{\rho}{\rho^0}\right)=0$,

$$(2)\quad \ldots \text{ or } \frac{1}{\rho}\frac{d\rho}{dt}=\frac{d}{dt}\left(\log\frac{\rho}{\rho^0}\right)=-c,$$

* "Maxwell's Treatise," Art. 325.

where c is a function of t only, and not of x, y, z, and ρ^0 is the equal of ρ at the time $t=0$. As we have

$$\frac{1}{m}\frac{dV}{dn}\frac{dm}{dn}=\frac{dV}{dx}\frac{d}{dx}\left(\log\frac{k}{\kappa}\right)+\frac{dV}{dy}\frac{d}{dy}\left(\log\frac{k}{\kappa}\right)+\frac{dV}{dz}\frac{d}{dz}\left(\log\frac{k}{\kappa}\right),$$

where $m=\frac{k}{\kappa}$ and n is a line in direction of the current at the given point, equation (1) becomes

$$\frac{1}{m}\frac{dV}{dn}\frac{dm}{dn}-\frac{1}{k}\frac{d\rho}{dt}-\frac{4\pi\rho}{\kappa}=0.$$

From equation (2) $\rho=\rho^0\epsilon^{-\int_0^t c\,dt}$, and hence

$$\frac{1}{m}\frac{dV}{dn}\frac{dm}{dn}+\rho^0\epsilon^{\int_t^0 c\,dt}\left(\frac{c}{k}-\frac{4\pi}{\kappa}\right)=0.$$

If we denote the strength of current at the point S, we have $S=-k\frac{dV}{dn}$, and

$$(3)\quad \ldots \frac{1}{cm-4\pi m^2}\frac{dm}{dn}=+\frac{\rho^0}{S}\epsilon^{\int_t^0 c\,dt};$$

this equation (3) gives the value of $\frac{k}{\kappa}=m$ at all points of the body and at all times, so that the phenomenon of electric absorption shall not take place. As this equation makes m a function of x, y, z, s, and t, the relation in general is entirely too complicated to ever apply to physical phenomena without some limitation. Firstly, then, as c is only an arbitrary function of t, we shall assume that it is constant:—

$$\therefore\quad \frac{1}{cm-4\pi m^2}\frac{dm}{dn}=+\frac{\rho^0\epsilon^{-ct}}{S}.$$

The most important case is where m is a constant; then $\frac{dm}{dn}=0$ and $c=4m$, $S=S_0\epsilon^{-ct}$, $\rho=\rho^0\epsilon^{-ct}$.

In this case, therefore, we see that both the electrification and the currents die away at the rate c. The case where Ohm's law is true and the specific inductive capacity is constant is included in this case, seeing that, when k and κ are both constant, their ratio m is constant. But it also includes the cases where k and κ are both the same functions of V, S, or x, y, z, seeing that their ratio m would be constant in this case also.

When m is not constant, the chances are very small against its satisfying equation (4).

Hence, we may in general conclude that electric absorption will almost certainly take place unless the ratio of conductivity to the specific inductive capacity is constant throughout the body.

This ratio m may become a variable in several manners, as follow:—

1*st manner*.—The body may not be homogeneous. This includes the case which Maxwell has given, where the dielectric was composed of layers of different substances.

2*nd manner*.—The body may not obey Ohm's law; in this case k would be variable.

3*rd manner*.—The specific inductive capacity κ may vary with the electric force.

It is to be noted that the cases of electric absorption which we observe are mostly those of condensers formed of two planes, or of one cylinder inside another, as in a telegraph cable. Our theory shows that different explanations can be given of these two cases.

The case of parallel plates does not admit of being explained, except on the supposition that m varies in the first manner above given, or in this manner in combination with the others, for we can only conceive of the conductivity and the specific inductive capacity as being functions of the ordinate or of the electric force. As the latter is constant for all points between the plates, m would still be constant, although it were a function of the electric force, and thus electric absorption would not take place.

We may, then, conclude that, in the case of parallel plates, omitting explanations based on electrolysis or thermo-electric currents, the only explanation that we can give at present is that which depends on the non-homogeneity of the body, that is the case which Maxwell has given in the form of two different materials. Our equations show that the form of layers is not necessary, but that any departure from homogeneity is sufficient. It is to be noted that the homogeneity which we speak of is electrical homogeneity, and that a mass of crystals with their axes in different directions would evidently not be electrically homogeneous, and would thus possess the property in question. In the case of glass it is very possible that this may be the case.

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and it would certainly be so for ice or any other crystalline substance which had been melted and cooled.

In the case of hard india rubber, the black color is due to the particles of carbon, and, as other materials are incorporated into it during the process of manufacture, it is certainly not electrically homogeneous.

As to the ordinary explanation, that the electricity penetrates a little below the surface, and then reappears again to form the residual charge, we see that it is in general entirely false. We could, indeed, form a condenser in which the surface of the dielectric would be a better conductor than the interior, and which would act thus. But, in general, the theory shows that the action takes place throughout the mass of the dielectric, where that is of a fine grained structure and apparently homogeneous, as in the case of glass, and consists of a polarization of every part of the dielectric.

To consider more fully the case of a condenser made of parallel plates, let us resume our original equations. Without much loss of generality, we can assume a laminated structure of the substance in the direction of the plane Y Z, so that m and V will be only functions of the ordinate X. Our equations then become

$$\frac{d}{d\,x}\left(x\,\frac{d\,\mathrm{V}}{d\,x}\right) + 4\,\pi\,\rho = 0,$$

$$\frac{d}{d\,x}\left(k\,\frac{d\,\mathrm{V}}{d\,x}\right) - \frac{d\rho}{d\,t} = 0.$$

Eliminating ρ, we find

$$\frac{1}{4\,\pi}\,\frac{d}{d\,t}\,\frac{d}{d\,x}\left(x\,\frac{d\,\mathrm{V}}{d\,x}\right) + \frac{d}{d\,x}\left(k\,\frac{d\,\mathrm{V}}{d\,x}\right) = 0.$$

Now, let us make $\phi = x\frac{d\,\mathrm{V}}{d\,x}$, and as t and x are independent, we find, on integration,

$$\frac{d}{d\,t}(p - \phi_0) + 4\,\pi\,(p\,m - \phi_0\,m_0) = 0,$$

where ϕ_0 is the value of ϕ for some intial value x, say at the surface of the condenser, and is an arbitrary function of t, seeing that we may vary the charge at the surface of the body in any arbitrary manner. This equation establishes ϕ as a function of m and t only, and, as we have $\rho = -\frac{1}{4\,\pi}\,\frac{d\,p}{d\,x}$, p will also be a function of these only.

Let us now suppose that at the time $t = o$, the condenser is charged, having had no charge before, and let us also suppose that the different strata of the dielectric are infinitely thin, and are placed in the same order and are of the same thickness at every part of the substance, so that a finite portion of the substance will have the same properties at every part.

In this case m will be a periodic function of x, returning to the same value again and again. As ρ is a function of this and of t only, at a given time t, it must return again and again to the same value as we pass through the substance, indicating a uniform polarised structure throughout the body.

This conclusion would have been the same had we not assumed a laminated structure of the dielectric. In all other cases, except that of two planes, electric absorption can take place, as we have before remarked, even in perfectly homogeneous bodies, provided that Ohm's law is departed from, or that the electric induction is not proportional to the electric force, as well as in non-homogenous bodies. But, where the body is thus homogeneous, electric absorption is not due to a uniform polarisation, but to distinct regions of positive and negative electrification.

In the whole of the investigation thus far we have sought for the means of explaining the phenomenon solely by means of the known laws of electric induction and conduction. But many of the phenomena of electric absorption indicate electrolytic action, and it is possible that in many cases this is the cause of the phenomenon. The only object of this note is to partially generalise Maxwell's explanation, leaving the electrolytic and other theories for the future.—*American Journal of Mathematics.*

DIA-ELECTRIC.

BY ALEXANDER J. S. ADAMS, A.S.T.E.

In number four of *The Electrician* will be found, under the above title, an account of some investigations that were made with the object of obtaining definite information regarding the causation of sound in the telephone, and during which I elicited the interesting phenomenon of *dia-electricism* and its sonorosity. That article will, doubtless, have been carefully perused, so that it will here be merely necessary to premise my further remarks upon the sonorous properties of *dia-magnetism* in relation to the telephone by offering a simple theoretical exposition upon the cause of dia-electric sound.

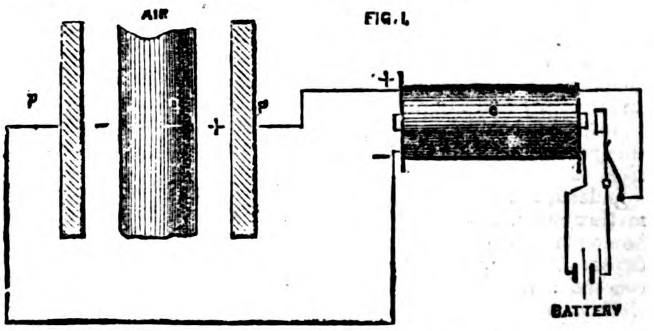
Let us try the following experiment:—Connect a flat piece of metal P, fig. I.—say a penny—to the positive end of an induction coil *c*, so that the metallic surface of the coin is intermittently charged, or electrified. Now, each time the surface of the penny P, receives a charge, the stratum of air *a* resting upon the penny receives a *similar* charge, and, as the air is but a partial, *i.e.*, slow conductor, ere the stratum has time to distribute its charge to the surrounding atmosphere, walls, floor, &c., a violent repellent action occurs between P and *a*; and the air being the more elastic it is driven from the penny, at the surface of which, for the instant, there exists a highly rarified space—a more or less perfect vacuum.

The production of this state, however, does not appear to produce the sound about which we are inquiring.

Immediately the air stratum *a* has, by what I conceive to be electrical radiation, got rid of its abnormal charge, the repellent force ceases, and the air by force of gravity falls back upon the metal P with a tap or click.

If, now, the number of changes produced by the induction-coil equal in time and number the vibrations of a given musical note, there will be a corresponding number of taps or concussions imparted to the penny by air impact, and the musical note is reproduced. This may be demonstrated by the inductophone.

If a second penny, *p*, be connected to the negative end of the induction coil C, and is brought near the first and positively charged penny, P, both the surface of *p* and its adjacent air stratum will receive a similar charge, and a repellent action is set up between them, resulting in an air impact upon *p*, at the same instant that a similar impact occurs upon P. Hence there are two opposite but simultaneous air vibrations, and a consequent augmentation in the intensity of the sound.



But the addition of the second surface *p* is the means of increasing the loudness of the sound to a still greater extent, by reason of the fact that there exists not only repellative forces between P and *a*, and *p* and A respectively, but that there is also a strong *attractive* energy exerted between the two strata, A and *a*.

We may now proceed to an examination of the sonorous properties of dia-magnetism.

Instead of an electrically-charged surface, we must have a magnetically-charged body, such as the core of an electro-magnet. Let, then, an electro-magnet occupy the place of the discs, P, *p*, so that the induced currents are free to circulate through its helix.

If, now, the end of a ruler—or, preferably, a deal cylinder—be caused to rest upon the electro-magnet core, and the experimenter's ear is placed at the other, it will be observed that with each repeated current a *faint* tap, or click, is produced in the electro-magnet.

Remove the deal cylinder, and place an armature upon the electro-magnet—a piece of iron of any size and shape, provided the adjacent core and armature surfaces are level and smooth—listen for sound as before, with the wood cylinder resting upon the armature; the former faint tappings will now have become loud. This intensified sound is the armature, or so-called telephonic sound; but how is it brought about?

Arrange so that the minute air space between the electro-magnet core and the armature is capable of being influenced by the air pump; it will be found that, upon exhausting this space, the sound previously audible will cease. This, however, is an expensive and difficult experiment, and much time and labour may be expended before the attainment of success, chiefly because of the peculiar character of air (it may be of gases also), whereby it appears capable of being highly electrified and magnetized up to within a little of what must be absolute vacuum; in other words, that, whilst the space between the core and the armature is being gradually exhausted, there is no corresponding diminution of sound; but that, upon reducing the vacuous state to a certain

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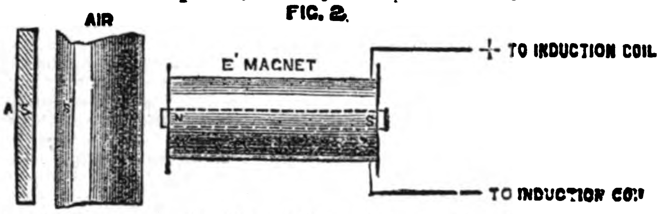
pitch of perfection, the sound will suddenly cease. I cannot as yet pretend to account for this peculiarity, however.

Try another experiment. Let the space between the core and armature form the interior of a cell, the respective sides of which are the core and the armature; then, whilst the telephonic sound is audible, fill the space with water to the expulsion of the air, and the sound will immediately cease.

But here is another and still simpler experiment, the means for which should be within the grasp of every one interested in the science of electricity. Having previously obtained audible telephonic sound, remove the armature, and smear it and the core-pole with a little Russian tallow. Replace the armature, and, curious as it may appear, the sound will have vanished.

From these experiments we have a clue to the causation of sound in the telephone, namely, that with every variation of

FIG. 2.



magnetic energy in the electro-magnet core N, fig. 2, the adjacent air stratum N' is *similarly* affected (of course, Faraday's diamagnetism), in consequence of which a repellent action is set up between them, as at N N'; and the air is driven from the surface of the core, leaving a rarified space, or vacuum. As the magnetic charge imparted to the nearest air stratum is gradually distributed by radiation to the surrounding atmosphere, the air adjacent to the magnet regains its normal condition, and falls back upon the core surface with a tap.

If, however, an armature, A, be brought near the electro-magnet core, both that armature and the stratum of air next it will be induced with an *opposed* magnetism S and S'; and they will consequently exert a repellative influence one upon the other. Hence, here also there are two simultaneous air vibrations in opposite directions, whereby the intensity of the concussions upon A and N are largely augmented.

But the *attractive* influence of the two oppositely-magnetized air strata, N' and S', one upon the other, also comes into play; and the force of each vibration and the ultimate impact is still further increased.

By inductive reasoning, it would also appear that this effect upon the air occurs only at the first instant of increase and decrease; that is to say, at the commencement of the variation in electrical and magnetic force.

Moreover, my investigations appear not only to have elicited the fact of dia-magnetism, but also to have confirmed my previous conviction, that, as inductophonic sound was simply an audible demonstration of dia-electricism, so also telephonic sound was an equally beautiful demonstration of the phenomenon of dia-magnetism.

In my own mind, too, there has long been a speculation as to how the transference of static and magnetic energy into heat, with a charged surface and a simple electro-magnet, was effected. Here, however, we have a solution of the mystery, in that heat is generated by the friction of air particles by the formation of the air wave, and by concussion of the air upon the electrified or magnetised body; and it is worth consideration as to how far the speed of electrical conductors, and of armatures moving within a magnetic field, are affected by dia-electric and dia-magnetic influences.

PRÆ-ELECTRIC TELEGRAPHY.

I.

Scientific men find so much difficulty in keeping astride of the progressive developements of knowledge that it is no wonder if they are sometimes too little acquainted with the first rude beginnings of their respective branches. Electricians especially, with so many and so wonderful inventions exciting them from month to month, have such good cause to press forward to what is before that they may well be too busy to look behind them. We offer no apology, therefore, for presenting our readers with some historical articles which we hope to make both useful and interesting. And, first, we propose to run over what had been done in telegraphy, that is, the art of *signalling to a distance*, before the employment of electricity.

From the very earliest times, we may suppose, fire was made use of as a means of conveying signals of triumph or alarm. In the Greek poets we read of Medea, Clytemnestra, and Leander, corresponding with their lords or lovers. It needed small measure of civilisation to suggest the use of beacons in a hilly country. Xerxes, whose vast states were for his time a model of orderly government, seems to have added to the postal arrangements which we described a few weeks back a telegraphic service for time of war. Heredotus says that, by means of torches placed at intervals on the island of the Ægean sea, the great King was informed at Sardis of the taking of Athens by his general. Cleomedes in his work "De Mundo," also commemorates another telegraph line, which, at the present rate of wages, would not be likely to pay a high dividend. Men were stationed at short distances apart, from Athens to Susa, who *shouted* the news from one to another; and it is declared, rather incredibly, that by this means a message had been transmitted from Greece to Persia in two days and nights. This curious line of telegraph, so liable to interruption, would seem to have been a mere temporary expedient. Aristotle relates that in the Persian empire itself a regular system of beacon signals was established, so that the king in his capital could receive information of an event which had happened that very day at the extremity of his dominions.

This statement may give an exaggerated idea of the telegraphic facilities enjoyed by Xerxes. The rate at which these signals were conveyed apparently implies a preconcerted arrangement for signifying the occurrence of some special event already foreseen. We have, at least, no record of a more complicated plan for communicating a number of emergencies till the century after Xerxes. Then Æneas Tacticus, a Greek writer on the art of war, first authentically presents himself in the long list of telegraphic improvers. His proposal is that the receiver and the transmitter shall be provided with two vessels, on the principle of the clepsydra or water clock, regulated to run down in equal time, and having divisions similarly marked, with pre-arranged sentences, such as "More transports wanted," "More ships of war," "Cavalry has arrived," and so on. When one of these messages had to be despatched, the telegrapher showing a torch and being assured by a like signal of the attention of his correspondent, the two clocks were to be set going. As soon as they had run down to the division against which was marked the desired message, the torch would again be shown, and the receiver would understand that he was now to examine his instrument, and would easily see, if all had worked regularly, that ships, or soldiers, or corn, or whatever it might be, was in question. This system is said to have been actually used by the Carthaginians in Sicily to telegraph to Africa for what supplies they required. But, when we consider the distance from coast to coast, we must be somewhat dubious. If, indeed, the story is to be taken as true, we commend it to the attention of that gentleman who is so much concerned in finding arguments to prove the earth flat.

Still, it will be seen that Æneas' plan could only include a limited number of contingencies, such as could be easily foreseen and provided for. In view of this deficiency, Polybius, the celebrated military historian, was led to suggest the use of an alphabet, a method which he declares to be not his own invention, but perfected by him. The less said about the "perfection" of his alphabetical method the better, for it is a clumsy enough affair. Like our own early telegraphists, he had recourse to what might be called a double-needle instrument. The twenty-five letters of the alphabet were divided into five tables, with five letters in regular order on each. The operator was to hold up from one to five torches on his left hand, to indicate which of these tables should be consulted; then the letter to be read on that table was counted according to the number of torches shown on the right. Polybius has also the credit of pointing out the influence which the necessities of telegraphy must have upon language; he discusses the art of "sending short." "Cretans, hundred, deserted" is the style which he recommends to the operators on his system. They must have had cause to be thankful that private cryptographic codes were not then invented. Communication by this method proved tedious and uncertain at the best; the main difficulty was to distinguish at a distance whether the torches were displayed to the right or left hand of the signaller, for which purpose Polybius proposed the use of a dioptric instrument. Had we flourished in those days, we think we could have taken out a patent for a very simple improvement. The torches on the right might have been held steadily up, and those on the left made to describe a quarter circle. But the only improvement we hear of in ancient times was that of Joachimus Fortius, who used only three lights and twenty-four letters, divided into tables of eight, one light being shown so many times to count off from the first eight letters, two lights in the second division, and three in the third. In case we should be getting undue credit for our display of classical knowledge, it must be confessed that we do not know who Joachimus Fortius was, but the fact is mentioned in Bishop Wilkins's curious book "Mercury, or The Secret and Swift Messenger."

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It is not improbable that Captain John Smith, the brave and sensible governor of Virginia, had read Polybius in his youth; we know, at least, that he studied Marcus Aurelius in his Lincolnshire hermitage. When warring against the Turks during his early adventurous career in the East, he, either profiting by this hint of the classical writer, or by the strength of his own native ingenuity, which seems to have excelled in what he terms "fireworks," called into play an adaptation of Polybius' torch telegraph for informing the besieged garrison of Olympagh of the arrangements which were being made for their relief. His code was even more simple. He divided the alphabet into two halves. The letters in the first half were counted with one torch, those in the second with two; and three lights were shown at the end of each word. This method of communication, at a distance of seven miles, was slow but sure, as the turbaned host found to their cost when they were attacked, before and behind, by the garrison and the relieving force at the same time.

Later, it has often been suggested to convey signals by alternately obscuring and revealing a light for longer and shorter intervals. This, if we may judge from a passage in his strange story, "The Man in the Moon," seems to have been the idea of Bishop Godwin, whereby, in the days of good Queen Bess, he got himself into serious suspicion, for in these times a man who was wiser than his neighbours was thought to get his cleverness from a very disreputable source, and Edison and Hughes might have contended for the honour of being burned with full public approval. We have here, of course, the principle of the Morse alphabet, which is so simple, and so adaptable to various means of addressing both ear and eye, that it has been, with some reason, proposed to teach it to all children in schools, so as to equip them with the power of making comprehensible signals that might be used in almost any circumstances. To return to ancient times: we get no further information unless it be in Vegetius, another military writer, who has one passage that appears to give some hint of the modern semaphore telegraph. "Beams," he tells us, "were sometimes suspended on towers of castles and cities, which being alternately raised and lowered, show what is going on." It would be strange, indeed, if by his time, when the Roman empire had long attained its highest point of civilization, and the military art had been so profoundly studied, some such obvious contrivance had not suggested itself. But now came the dark ages, swamping the world's stores of science, and it was many centuries before the art of rapid signalling became again, in the necessities of elaborate warfare, the subject of serious consideration. Alas! if it had not been for war, men would have been careless enough about the quick interchange of messages of peace.

[TO BE CONTINUED.]

CORRESPONDENCE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: A correspondent in your journal inquires if the increase of E.M.F. of one battery over another is not obtained chiefly, if not entirely, by a more rapid consumption of zinc.

The quantity of zinc consumed in batteries in producing a given current is inversely proportional to their respective E.M.F.'s. For example:—

If we assume the potential of a single bichromate element to be two volts, and its internal resistance ten ohms, we obtain a current of ·02 veber on a circuit of ninety ohms, and an evolution of ·75 cubic inch of mixed gases at the electrodes per hour.

This gas (equal to a reduction of ·364 grains of zinc) is evolved at every pair of electrodes in the circuit.

If we are producing the current from two Daniells' cells, of five ohms resistance each, instead of one bichromate cell, we shall, while producing the same exterior effect, have just twice as many decomposing cells in the circuit, and, consequently, double the amount of decomposition.

The question of your correspondent must, therefore, be answered in the negative.

The E.M.F.'s of voltaic elements are not dependent on the quantity of zinc consumed, but upon the energy of the chemical combinations.—I am, sir, yours truly, P. M. STEWARD.

Sept. 4, 1878.

The Eastern Telegraph Company's traffic receipts for the month of August, 1878, amounted to £35,839, and to £40,423 in the corresponding period of 1877.

THE ELECTRIC LIGHT.

At the meeting on Friday week of the Barnet District Gas and Water Company, Sir J. F. Bontems presided, and in the course of his observations, in moving the adoption of the report, said: I don't know whether any of our shareholders have turned their attention to the electric light, but I have. I see that in London there is some weakness manifested in the price of gas shares, on account of what has been said and written about the electric light. I have made inquiry, and have listened to what has been said by people who are very good authorities upon the subject; and I don't think, even in the metropolis, there is much fear of any injury being at present inflicted upon gas shareholders by the electric light. We don't know what improvements may take place, but, whatever may happen in London, I think it will be a long time before the hills and valleys of North Middlesex are lighted by the electric light. I don't think we need have much fear of any harm coming to us in that direction. Mr. Glaisher, in his remarks in seconding the adoption of the report, said, referring to the same subject: I have taken great interest in the probable effect of the electric light upon gas property. I have seen it at Havre and in Paris. When it is remembered that it requires a 70-horse power engine for about sixteen lights, I think it will be acknowledged that the expense is so great that it will be a long time before the electric light can come into general use, even for large spaces. In 1851 I was one of the jurors at the International Exhibition, and the electric light was then brought under my notice. Comparing what was then done with what can be done now, there has certainly been progress, but very little, considering the number of years which has since elapsed; and, although the price of gas shares has gone down in the market, I am convinced that, unless the progress is much greater in coming years, shares will resume their normal value, and dividends will not be affected.

RECENT PATENTS.

4847. TELEPHONIC APPARATUS, *C. A. McEvoy.—Dated 20th December, 1877. 6d.*

One apparatus is used for sending and receiving a message. For this purpose the apparatus is formed with a pipe leading from the chamber in rear of the metal disc, the chamber being somewhat deeper than usual, and at the end of the pipe is attached a small trumpet mouth, into which the message to be sent is spoken, the pipe is formed with elbow bends, so that, when the apparatus is held so as to bring the metal disc near to the ear of the person using the apparatus, the trumpet mouth may be at a short distance in front of his mouth.

4934. ELECTRIC TELEPHONY, *C. W. Harrison.—Dated 20th December, 1877. 6d.*

A conversation may be carried on at a distance through a connecting wire by speaking direct upon the electrodes of a thermo battery, and thus producing from the warmth of the breath a thermo-electric beat corresponding with the air wave produced by the voice. A galvanic or voltaic battery is used for the production of electricity, the electrodes being separated by a moistened substance, and the wave or beat is produced as in the former case. A flat spiral coil of wire is attached at each end of the line wire, and the words are spoken upon the coil at one end, and are reproduced at the other end.

58. ELECTRIC TELEPHONES, *G. Stephenson.—Dated 4th January, 1878.—(Not proceeded with.) 2d.*

In telephones where a horseshoe magnet is used in conjunction with a vibrating disc, such disc is placed between the two poles of the magnet. Between one pole and the corresponding surface of the disc is a piece of soft iron surrounded by the coil, and at the opposite side is another piece of soft iron in the form of a tube, like a lining to the neck of the mouthpiece. The poles and the two pieces of soft iron are adjustable, so that the disc may be brought into equilibrium.

TELEGRAPH SHARE LIST.

COMPANIES.	CLOSING PRICES SEPT. 4.		BUSINESS DONE WEEK ENDING SEPT. 4. Highest.	Lowest.
Anglo-American	60¾,	61¼	61	60¾
Do. Preferred	90½,	91	90¾	90½
Do. Deferred	33½,	31½	34	33¾
Brazilian	6¾,	¼	—	—
Cuba	9¼,	¾	—	—
Do. Ten per Cent. Preference	16¼,	¾	—	—
Direct Spanish	1,	¼	—	—
Do. Ten per Cent. Preference	9½,	10	9¾	—
Direct United States	13½,	¾	13¾	13
Eastern	7¼,	¾	7½	7 5-16
Do. Six per Cent. Debenture	106,	108	—	—
Do. Five per Cent. do.	99,	101	—	—
Do. Six per Cent. Preference	11¼,	¾	11¾	11½
Eastern Extension	7¼,	¾	7½	7¾
Do. Six per Cent. Debenture	106,	109	107½	106¾
German Union	8,	½	—	—
Globe Telegraph and Trust	5 5-16, 7-16		5½	5 7-16
Do. Six per Cent. Preference	10 15-16, 11 1-16		11½	10⅞
Great Northern	8¼,	¾	8¾	8½
Indo-European	20,	21	20½	20½
Mediterranean Extension	3,	½	—	—
Do. Eight per Cent. Preference	9½,	10	—	—
Reuter's	10,	11	—	—
Submarine	218,	223	—	—
West India and Panama	2½,	¾	2½	2½
Do. Six per Cent. Preference	8¾,	¾	8¾	—
Western and Brazilian	4¾,	¾	—	—
West. Union 7 p. Cent. 1st Mortgage	114,	118	—	—
Do. Six per Cent. Sterling	99,	101	—	—

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NOTES.

TELEGRAPHS AT PARIS.—The length of line in use in this city is about 4,544 kilometres.

SOUNDERS.—We are informed that the postal authorities have decided to introduce the Sounders, as designed by Mr. Elisha Gray, of Chicago, into the English offices.

EASTERN TELEGRAPH COMPANY.—The Eastern Telegraph Company notify the repair of the Amoy-Shanghai cable, thus restoring telegraphic communication with Shanghai, "*viâ* Eastern."

GREAT NORTHERN.—The Great Northern Telegraph Company's cable between Shanghai and Amoy is restored. Messages are, therefore, again received for all stations in China and Japan.

THE RONALD'S CATALOGUE.—In our note on this subject last week, it was erroneously stated that the Catalogue contained 1,200, which should have been 12,000 entries. The librarian desires us to state that he will be happy to send specimen pages on application to the Society of Telegraph Engineers, 4, Broad-sanctuary, S.W.

MICROPHONE IN INDIRECT CIRCUIT.—Mr. A. Chiddy says:—"It is not absolutely necessary that the microphone should form part of the direct circuit. It works just as well if connected so that, when the carbons are not touching, the whole of the current goes through the telephone. When the carbons are together a small portion will, of course, leak through them; upon this leakage depends the rise and fall of tension in the receiver. For some experiments it is even better to work the microphone in this indirect manner, as the circuit always remains closed, and prevents, in a great measure, the *jarring* noise resulting from a break.

CHEMICAL SOCIETY.—The Chemical Society have lately made the following grants from their Research Fund:—50*l.* to Dr. Tilden, for an investigation into the chemical nature of the terpenes; 50*l.* to Mr. W. N. Hartley, for apparatus and materials required in carrying on a research on the action of organic substances on the ultra-violet rays; 30*l.* to Dr. W. Ramsay, for determining the electric conductivity and resistance of solutions of salts at different temperatures; 20*l.* to Mr. W. Jago, for the purchase of apparatus required for carrying on a research on the organic matter in sea-water; 10*l.* to Mr. W. A. Shenstone, for an examination of certain reactions of brucine and strychnine.

WENZEL'S NICKEL ANODE.—The difficulty that attends the operation of making plates of pure nickel for battery anodes has rendered it imperative that something should be devised which would render possible the use of ordinary grain nickel for such a purpose. A nickel holder has been divised, consisting of a flat box made of ordinary battery carbon, and having perforated sides, between which the grains of nickel are held loosely, so that the bath solution may come into contact with the entire surface of each grain. The holder is provided with a hook by which it is suspended from the battery wire. The perforated carbon plates and the strips that separate them are clamped together by rubber bolts, which are provided with milled nuts, so that the holder may be readily taken apart for cleaning, and, as the top of the holder is open, the grains of nickel may at any time be readily removed for washing.

A YEAR'S TROUBLES IN GERMANY.—From a report recently issued, it appears that the number of troubles on the German telegraph lines last year was somewhat larger than usual. One hurricane put temporarily out of service nearly two-fifths of all the lines. The total number of derangements during the year was 6,198, of which 87 per cent. were country lines, 7 per cent. town lines, $1\frac{1}{2}$ per cent. cables, and $4\frac{1}{2}$ per cent. office leads; 26 per cent. were due to atmospheric influence, 15 per cent. to falling rocks, or earth slips, 3 per cent. to mischief or carelessness, 3-10ths per cent. to the flight of birds against the wires, or kite strings. The remaining 54 7-10ths per cent could not be accounted for. The troubles were 1,708 broken posts, 3,284 broken wires, 4,114 damaged insulators, 2,706 broken binding wires. The system in which they occurred only comprised in the year 1876, 37,264 kilometres of line, involving 136,891 kilometres of wire.

THE TELEPHONE AND TERRESTRIAL MAGNETISM.—M. de Parville has just suggested the use of the telephone for determining the position of the magnetic meridian—that is to say, the true direction of the magnetic needle. It is sufficient to take a Bell telephone, of which the magnetic core consists of a bar of iron a metre long, suspended with an angle of inclination similar to that given by an inclination needle. Under the influence of terrestrial magnetism this bar becomes magnetic, and the telephone can transmit the sounds produced by any vibrator placed near its mouth. These sounds are naturally stronger as the magnetism of the bar increases, and, if the telephone be turned round the horizon, keeping the bar at the same inclination, the sounds transmitted in the receiving telephone are at their maximum when the axis of the bar is the plane of the magnetic meridian, and at their minimum when at right angles to this direction. Thus, by the direction which this axis occupies when the sounds are inaudible, can be recognised the exact direction of the magnetic poles. By this system the influence of the masses of iron which so sensibly affect the magnetic needle on iron ships would be almost *nil.* An orientation more exact than that of the compass can be obtained. The same process could be applied to measuring the variations of the earth's magnetism.

THE BLOWING UP OF HELL GATE AT NEW YORK.—*La Nature,* in the issue of Sept. 7, gives details of the use of electricity in this gigantic operation. The electricity for the purpose of igniting the dynamite cartridges, containing 50,000 kilogrammes of dynamite, was obtained from a bichromate of potash battery, consisting of forty-eight cells, each containing ten elements. The zincs and carbons were arranged so that they could be raised from or lowered into the exciting fluid at pleasure. To obtain the exciting fluid, 80 kilogrammes of bichromate of potash were dissolved in 650 litres of water and 130 litres of strong sulphuric acid. The cells were thus grouped:—Seven batteries of 44 elements each, four of 43 elements, and twelve of 40 elements, and each battery was expected to explode eight groups of 20 cartridges. The cartridges were connected by conducting wires to little cups filled with mercury. Above these cups a metallic plate, connected with the battery and held by a rope, was placed, so that when it fell contact was immediately made. The rope held a cartridge, connected through a key with a cell. At a certain time the carbons and zincs were lowered into the exciting fluid. The daughter of General Newton pressed the key, the cartridge connected with the rope exploded, the rope was broken, and the contact plate descended, making the mine contact, and the dynamite exploded. The success, as we all know, was complete, and we only refer to the affair to show the part played by electricity.

THREE EXPERIMENTS WITH TELEPHONES, BY PROFESSOR E. SACHER.—In order to ascertain what were the feeblest

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induced currents in the telephone that would be sufficient to produce in the ear distinct sensations of sound, on December 27, 1877, I made the following experiments:—1. I led the closed current-circuit of the telephone, at twenty metres distance, parallel with the wire, well insulated with linen and wax, of an ordinary telegraph-apparatus. The signals were given at first by six, and afterwards by three Smee's elements ($\frac{1}{20}$ H_2SO_4); and they were, through the induced currents in the telephone, so distinctly audible that the message (by the two signals, long and short) could be understood. 2. I effected a division of the current by uncovering two places in the insulated wire distant from each other twenty metres, and fixing there the ends of a telephone-wire of equal strength and 120 metres long. Reckoning, in addition, the thin wires in the interior of the telephone, certainly only a small portion of the current went through it; and yet the rap was perceived with sufficient distinctness for the message this time also to be understood. (Hence it is easy to tap the messages of any open telegraph-line if one can learn to read the Morse alphabet by hearing.) Experiment 1 succeeds also when the telegraph-wire is connected with the thick, and the telephone-wire with the thin wire of a Ruhmkorff. If we wish to perceive the signals more distinctly, it is advantageous to appropriate two telephones to the hearing; it is then, moreover, better to close the other ear against external noises. 3. I connected the telephone-wire, about forty metres long, with the inner thick wire of an ordinary induction-coil, and the wire, 120 metres in length, of a second telephone system, with the outer thin wire. To my great surprise, we could correspond both from the first to the second telephone, and also (indeed apparently still better) in the reverse direction, nearly as well as with the connexion direct. The words were heard still more distinctly when I inserted in the same manner two induction-coils. On the contrary, the experiment was a failure when a Ruhmkorff was employed in this way; the sound was too faint.—*Kaiserliche Akademie der Wissenschaften in Wien, math.-naturw. Classe.*

Gas Shares and the Electric Light.—"It ought to have been clear to the most ordinary mind that the day was not far distant when some other illuminating power would come into competition with gas. Strange to say, the chairmen of the various gas companies have persistently assured their proprietors that they had nothing to fear from the competition of electricity. They must have been very superficial observers indeed of passing events to have given expression to any such opinion. However, it had the effect of quieting the anxieties of the proprietors, but it cannot be ignored that there is at last a slow awakening to the fact that we are on the eve of a great revolution in the lighting of our cities and towns. The holders of gas shares are a very conservative class—strong in prejudice, and firm in the belief of any idea which they have once formed. For many years they have had not only a handsome income from their shares, but a considerable bonus in new issues from time to time, which have been very gratifying to them. But all this piling up of capital, from which they have derived increased profit, has been at the expense of the consumer, who naturally felt somewhat rebellious at the burdens imposed upon him by the companies. Now that there is a prospect of emancipation from the monopoly which has so long existed, the consumer welcomes with thanksgiving any invention which is likely to break it down. Gas companies have certainly not made friends with the public, who now welcome the moment of retribution. I have witnessed experiments in electric lighting which were most convincing. It is to be seen at the present moment in Paris and Madrid. It is also to be seen nearer home, at Dover, where two brilliant electric lights have been in use for years. It is, therefore, only right to warn holders of gas shares that they should not be indifferent to what is passing around them, and, as I know many instances where investors have nearly all their property in this particular kind of security, they should anticipate events, and divide it over a wider area in various investments at home. I do not look for a panic in gas property, but symptoms are not wanting that, if holders should take fright *en masse*, very much lower quotations will be witnessed, and the hint, if taken now, may save a good deal of regret later on." The above is the opinion expressed by one of the most prominent brokers in his circular to clients.

Captain Sale's System of Transmitting Sound.—Captain M. T. Sale, R.E., has patented improvements in apparatus for taking-up, sending, and repeating voice sounds by electricity to and from distant stations or places. According to this invention, the voice acts as a regulator, and not as a source of power, whereby the strength of vibration of a metal disc, and consequent loudness of articulate speech at the receiving station, are not limited by the strength of voice of the speaker at the sending station. The apparatus consists essentially of a plate or membrane which vibrates to the tones of the voice. This membrane or plate causes to be introduced into a voltaic circuit a resistance which varies exactly as the plate or membrane vibrates. The current flowing along the line being (the source being constant) exactly as the total resistance of the circuit, it follows that the current passing at any point in the line varies as the membrane or plate vibrates. These currents passing through the coils of a suitable electro-magnet, permanent magnet with coils, or polarised electro-magnet, excite, in an armature which takes the form of a plate, vibrations which correspond with those of the membrane or plate of the sending station; but the vibrations of the plate at the receiving station can be heightened at will by the introduction of an increased battery power in the circuit. This effect is obtained by means of a circuit metallic plate held by the collar against a disc which is perforated by the mouthpiece. The plate is free to vibrate in a manner similar to a drumhead, and carries at its centre a light stud, which is covered with platinum. A fine screw is so placed working in a rigid standard that its platinum-covered end can be brought into contact with the stud above mentioned, or receded from it at will, the distance between the screw and the stud being capable of fine adjustment. The metal standard, in which the screw works, is connected with a terminal screw, to which the line wire is attached, whilst the metallic plate, and with it the stud, are placed in connection with a terminal screw, to which one pole of a battery is connected, the other pole of which is to earth or return wire. In order to work the instrument a drop of a fluid or semi-fluid substance, or a flame such as to be an imperfect conductor, but to be as little as possible liable to electrolytic action, is placed between the end of the screw and the stud, and the screw is made almost to touch the stud. On speaking into the mouthpiece, as the plate vibrates to the tones of the voice, the distance between the end of the screw and the stud varies with each vibration, and as the distance varies so does the resistance offered by the drop of fluid substance between the contact points vary. With the varying resistance a varying current passes along the line. This vibrating current is received at the distant station on an electro-magnet, or permanent magnet coiled, or on a polarised electro-magnet, and there operates by the varying attraction of a thin iron plate or diaphragm placed in front of it. This invention, it will be seen, is only a modification of the earlier American telephones.

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ON TELEPHONY.

By W. Siemens.*

The surprising performances of the telephones of Bell and Edison rightly claim in a high degree the interest of natural philosophers. The solution (facilitated by it) of the problem of the conveyance of tones and the sounds of speech to distant places promises to give mankind a new means of intercourse and culture which will essentially affect their social relations and also render substantial service to science; and hence it seems fitting that the Academy should draw these exceedingly promising discoveries into the sphere of its contemplations.

The possibility of reproducing mechanically not merely tones, but also noises and spoken sounds, at great distances is given theoretically by Helmholtz's path-opening investigations, which elucidated the essential nature of shades of tone and the sounds of speech.

If, as he has demonstrated, noises and sounds are only distinguished from pure tones by the fact that the latter consist of simple, the former of a plurality of series of undulations, superposed to one another, of the sonorific medium, and if the noises of speech *(Sprachgeräusche)* may be conceived as irregular vibrations with which the vocal sounds begin or end, then it is also possible to reproduce mechanically a certain succession of such vibrations at distant localities. Indeed practical life has in this, as is frequently the case, outrun science. The hitherto too little regarded so-called "speaking telegraph," consisting of two membranes stretched by a strong and at the same time extremely light thread or fine wire which is fastened to their centres, effects a perfectly distinct transmission of speech to a distance of several hundred metres. The threads or wires can be supported at any number of points by elastic threads of a few inches length, and also, with similar elastic fastenings at the angles, from any number of angles, without the apparatus losing the capability of conveying with perfect distinctness and correctness completely toneless whispered speech—a performance which previously no electric telephone could accomplish. Although this "speaking telegraph," or, more correctly, "thread telephone," possesses no practical value (since its working is still limited to short distances and is interrupted by wind and rain), yet it is most deserving of notice, because it proves that stretched membranes are fitted to take up, almost completely, all the air-vibrations by which they are struck, and to reproduce in another place all speech-sounds and noises when mechanically put into similar vibrations.

Reis, as is well known, was the first to endeavour to operate the conveyance of tones by electric currents instead of a stretched thread. He made use of the vibrations of a membrane exposed to sound-waves to produce closing contacts of a galvanic series. The current-waves hereby generated traversed, at the other end of the conduction, the coil of an electromagnet, which, provided with a suitable resonance-arrangement, again produced approximately the same tones by which the membrane, struck by the sound-waves, had been set vibrating. This could only be done very imperfectly since the contact-arrangements only became effective with the greater vibrations of the membrane, and could only imperfectly render even these.

Bell appears first to have had the happy thought to let the vibrating membrane itself call forth the currents serving for the transmission of its vibrations—making it of soft iron, and placing its centre opposite and very near to the end of a steel magnet wound round with insulated wire. By the vibrations of the membrane, the attraction between the plate and the magnet, and therewith the magnetic potential of the wire-enveloped end of the bar-magnet, were alternately augmented and diminished; by this, in the wire of the coil and in the conduction, currents were produced which, with the minuteness of the vibrations of the plate, generated electrical sine vibrations corresponding to the vibrations of the mass of air, which were thus in a condition to call forth again membrane- and air-vibrations in a similar apparatus at the other extremity of the conduction. The result was unaffected by the circumstance that, as Du Bois-Reymond† has pointed out, in the receiving membrane the phases and ratios of amplitude of the partial tones are different from those in the emitting membrane.

An essentially different path was struck out by Edison (as it appears, simultaneously with Bell). He uses a galvanic series, which sends a constant current through the conduction.

At the sending end a layer of powdered graphite, which is gently pressed between two metal plates insulated one from the other, is inserted in the circuit. The upper plate is fastened to the vibrating membrane, and presses the graphite powdered more or less together in correspondence with the air-vibrations. By this the resistance of the graphite to conduction is correspondingly varied, and thereby sinusoid variations, equivalent to the air-vibrations, are produced in the intensity of the current passing through the conducting line. As receiving-apparatus, Edison uses no membrane, but another and quite peculiar contrivance. It is based on the experience that the friction between a piece of metal and a paper band saturated with a conducting fluid and pressed against the metal is diminished when a current passes through the paper to the metal. I have verified this remarkable phenomenon for the case in which the direction of the current is such that hydrogen is separated at the metal plate, or when the metal is not oxidizable. Hence the lessening of the co-efficient of friction by the current evidently proceeds from electrolytically generated gases deposited on the plate of metal. Surprising, however, remains the almost instantaneous rapidity with which the effect takes place even with very feeble currents.

Now, Edison attaches the metal plate, pressed against the moist paper, to a sounding-board, and draws the moist paper, which is carried over a roller, under the metal piece by continual rotation of the roller. If, now, the metal piece and the roller (also of metal) be inserted in the galvanic circuit, the variations produced in the current by the greater or less pressure of the graphite powder effect equivalent variations of the friction-coefficient between the metal plate attached to the sounding-board and the paper, whereby the former is put into corresponding vibrations, which are communicated to the sounding-board, and through this to the air.

Edison's telephone is very remarkable on account of the novelty of the expedients employed in it; but it is obviously not yet complete for practical use; while Bell's telephone has, in its remarkably simple form, been widely spread in a short time, especially in Germany; and already much material of experience has been accumulated for judging of its usefulness. Its principal defect consists in the feebleness of the reproduced sounds, which, in order to be distinctly understood, require the sound-aperature to be pressed to the ear, and at the other end an immediate speaking into it. Perfect quiet is necessary around it, in order that the ear may not be dulled and disturbed by extraneous noises. A still graver obstacle to its practical employment consists in this—that it needs complete electrical calm. As the currents are extraordinarily feeble which are generated by the vibrating iron membrane and put the membrane of the other instrument into similar vibrations, therefore also very weak extraneous currents are sufficient to disturb the latter and bring to the ear confusing noises of other origin.

In order to procure fixed points for judging the intensity of the currents which are effective in the telephone, I placed one of Bell's telephones, the magnet-pole of which was wound round with 800 turns of copper wire 0·1 millim. thick and possessing a resistance of 110 mercury units, in a circuit containing a Daniell's cell, with a commutator, by which the direction of the current was reversed 200 times in a second.

Without an inserted resistance, these current-waves produced in the telephone an extremely inharmonious noise, audible at a long distance, and almost intolerable close to the ear. By the insertion of a resistance, this noise was diminished, but was still very loud after the insertion of 200,000 units. If 6 Daniells were inserted, the noise was still distinctly audible through ten million units of resistance. If 12 Daniells and twenty million units of resistance were inserted, the sound was decidedly more distinct than in the last preceding case. In like manner an increase in its intensity took place when thirty and fifty millions of units were inserted with 18 and 30 Daniells respectively. This corroborates Beetz's observation that electromagnetism, with equal current-intensity, is more quickly called forth in circuits of great resistance by correspondingly more intense electromotive forces, than in circuits with little resistance and proportionately less electromotive forces, because the countercurrents which arise in the windings of the electromagnet count for more in the latter case than in the former.

If in the circuit of the commutator the primary spiral of a small voltaic induction-coil was inserted, such as is ordinarily employed by physicians, while the telephone and resistance-scale were in the circuit of the secondary wire, with one Daniell element a loud-sounding noise was still obtained when fifty million mercury units were inserted; and this remained distinctly audible even when the secondary spiral was pushed back right to the end of the primary.

[TO BE CONTINUED.]

* Translated from the *Monatsbericht der königlich preussischen Akademie der Wissenschaften zu Berlin.*

† *Archiv für Physiologie*, 1877.

PRÆ-ELECTRIC TELEGRAPHY.—II.

As fire was the means used for signalling in ancient times, so the semaphore was the main feature of modern telegraphy before

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the employment of electricity. This invention was first practically employed in France, though in 1864 the English physicist, Robert Hooke, had suggested something of the kind.

About the time that Napoleon was building snow castles at Brienne, the Abbé Claude Chappe was a novice in the seminary of Angers, and had two brothers at a school in the neighbourhood. Most schools in France are managed somewhat upon the cloister principle, and the brothers, probably, not often being able to see one another, are said to have devised a means of corresponding from their respective prisons by means of one stick pivoting on the top of another, so as to form different angles. The Revolution came on; the coalition of kings threatened the national Government of France, and every patriot's mind was stirred with zeal to serve his country in that critical time. Then the Brothers Chappe bethought themselves of their youthful diversion, and proposed to turn it to account in resisting the national enemy. After considering and rejecting several methods of signalling, based upon combination of colours and chronometrical intervals, they, in 1793, brought under the notice of the Government a system which seemed to fulfil the desired conditions. To their apparatus they first gave the mame of the *tachygraph* (from the Greek words for *quick-write*); but this was soon changed for that which has now become a familiar word in every civilized language.

The Convention, being a *parvenu* Government, dependent for existence on its own exertions, totally forgot the duty of snubbing inventors, so well recognised by more dignified rulers, and soon encouraged the ingenious brothers by a vote of 6,000f. to defray the expenses of an experiment. The apparatus was found to work so well that an experimental line was constructed at a further expense of 100,000f., and Claude Chappe was appointed telegraph engineer to the army. A chain of stations being established between Paris and the northern frontier, where the fighting was going on, this first telegraph line was inaugurated on Nov. 30, 1794, by news of a victory over the Austrians. The success of the new invention was now complete. It was gradually extended to different parts of France, till, at the introduction of the electric telegraph, there were six chief semaphore lines of about 5,000 kilometres, with more than 500 stations. The semaphore was used, perhaps for the last time, at the siege of Sebastopol. For about fifty years it was a conspicuous feature of French scenery, and readers of Dumas will remember an exciting scene in "Monte Christo" which turns upon its employment.

The signals of Chappe's semaphore were those afterwards reproduced by the needles of the Foy-Bréguet electric telegraph. When in rest it resembled a gigantic "T." The top line was called the *regulator*, the side strokes were the *indicators*. These were jointed and moved by pulleys in such a way that they could be made to form different angles with respect to each other. It is easy to see how these combinations of angles might be multiplied, like the comical figures of a well-known child's toy. When the regulator was bent obliquely to the left or the right, ninety-two signals could be made in each case. Those on the left were understood by all the staff, and were used for the necessary correspondence of the service; while those on the right referred to a code which was in the hands only of confidential interpreters at either end, secresy being a matter of importance for Government messages. The code contained ninety-two pages, each of ninety-two words, so that a double signal, first for the page, then for the word, could indicate from a vocabulary of more than 8,000 words. The stations, about three leagues apart, were, of course, erected on any convenient eminences, the towers of churches and castles being utilized without scruple by the Revolutionary Government. Two watchers were always on the look out, who received the signals from either side, and, repeating them as formed, transmitted them to the next station. Each signal took from ten to twenty seconds to deliver, but, in practice, it was found that no more than sixty signals could, with certainty, be transmitted in an hour. When all worked well, a message could reach Paris from Lille in two minutes, from Strasbourg in six minutes, and from Toulon in twenty minutes.

Before leaving Claude Chappe, it may be mentioned that he was not more fortunate than many other inventors. The pretensions of rival claimants to his idea preyed upon his mind, and he drowned himself before reaching the age of forty. His contrivance was, indeed, so obvious that there was room for disputes as to priority of invention. It was, of course, suggested by the sails of a windmill, which are said to have been long ago used by the smugglers of the Suffolk coast for making signals to their confederates. When the English soldiers first saw the telegraph in operation it was in the rude form of a windmill, with two of the sails removed, and a sack of hay dangling from one of the ends, which caused our troops to think that the French were hanging a man from a windmill. There is also an American claim to the idea. In the revolutionary war some Edison of the period is said to have hit on the device of signalling with a barrel, a basket, and a flag, at the top of a high pole.

The value of the French telegraph was soon recognised, and it was introduced into other countries, with various modifications in the mode of signalling which it would be too long and little interesting to describe. John Bull, of course, had his own way of doing things. The Rev. J. Gamble, chaplain to the Duke of York, to whose learned work on telegraphy we are indebted for much of our information, and who, in the campaign of 1793, had seen the Chappe apparatus at work, hastened to bring forward a plan which seemed to him an improvement. His first proposal was a series of long boards, made to turn on pivots; in fact, a great Venetian blind. Afterwards he constructed a radiated telegraph of five fingers, to work somewhat upon the principle of the deaf and dumb alphabet. The Government, however, preferred a scheme submitted by Lord George Murray, in which the letters were formed by the opening and shutting of six square boards, working upon pivots. This was eventually superseded by a semaphore telegraph.

The climate of England must always have been sadly against the constancy of these communications. "Interrupted by the fog" was a common feature of telegraphy in these days. A story is told of the anxiety caused to our grandfathers during the Peninsula War, by a message which began, "Wellington defeated—" there the transmission was abruptly broken off. When the weather permitted, it was happily found to read, "*Wellington defeated the French at* ——." By night, of course, the telegraph was always useless. Contrivances of lamps, with reflectors, in the style of our present railway signals, were found unavailing. We have in our possession a correspondence between the Admiralty and Dr. Meyrick, of Doctor's-commons, in which he proposes to use flames of carburetted hydrogen gas, their number and position to be distinguished by a dioptric instrument affixed to a telescope; and by this time science would, no doubt, have found a fit expedient, even if Morse and Wheatstone had not solved the difficulty in the effectual manner which has for ever disposed of all those clumsy contrivances.

We hope to treat the beginnings of electric telegraphy in a separate article. Our readers would, probably, not thank us for a full description of the various other devices which were used or proposed for signalling—flags and balls by day, like the naval signals now in use—rockets and coloured lights, for night service —reflecting mirrors—sound sent through long tubes—concerted discharges of artillery. One, perhaps, deserves special mention. Mr. D. Brent's plan was to take advantage of the well-known property of water to rise to its own level. So, let a pipe, A. B., be laid from London to Dover, with a perpendicular tube, A. C. and B. D., at each end, and these pipes be constantly filled with water to a certain height; then, on adding any quantity of water to the tube, A. C., the water in the other tube, B. D., would be elevated equally, and intelligence might be conveyed by means of letters adapted to the two tubes at corresponding heights.

In reviewing and deciding against this method, Mr. Gamble sagaciously observes:—"Full as many if not greater objections will probably operate against every contrivance where electricity shall be used as the vehicle of information. The velocity with which this fluid passes when the conductors are tolerably perfect, and also that it may be made to pass through water to a very great distance, when it forms part of the circuit, are properties which appear to have given rise to the idea of using it as a medium of correspondence. I have never heard it mentioned that an alarm may be given to a very great distance by firing a pistol charged with inflammable air, which explodes by the smallest spark of electricity; but the further communication could only be maintained by a certain number of shocks, being the preconcerted signal of each letter, and requires that the man who receives the intelligence should remain constantly in the circuit of the electric fluid. The whole success of the experiment would likewise depend on an apparatus liable to an infinite number of accidents scarcely in the power of human foresight to guard against."

After this, the reverend gentleman, who thus undertook to prophecy *ultra crepidam*, was clearly right in concluding his work with a sentence of the wiser Seneca:—*Veniet tempus, quo ista quæ nunc latent, in lucem dies extrahet et longioris ævi diligentia.*

THE PARIS EXHIBITION.—II.

It would be a huge task, and far beyond the powers of any one pen, to attempt to describe the Paris Exhibition, and we are thankful that one small portion only has to be reviewed at our hands. Some of our readers may have noticed a paragraph we quoted from the *Scientific American* in our issue of August 31, entitled "A Chance for Inventors." Our contemporary re-echoed an old, old tale, that wooden telegraph-posts soon decay in India

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and other parts possessing a similar climate. The quick decay, however, is not always caused by climatic influences, but frequently by the ravages of ants and other insects. Iron posts, it is said, have been tried, "but neither the cost nor the style gives satisfaction." Our contemporary is certainly not acquainted with the display of iron telegraph posts made at the entrance to the French electrical department at the Exhibition, or it would have seen some poles very much resembling those it suggests as being required. The visitor will, in fact, find a fairly complete selection of iron telegraph posts fit for almost any purpose, or any climate. Light poles of "T" and "H" angle iron, to carry from one to a dozen or so wires, are shown, whilst larger and stronger poles of various designs and section, capable of carrying 40 or 50 wires, are to be seen. The following table of the poles, shown by the Administration of the Telegraphs, as designed by M. de la Taille, engineer of telegraphs at Orleans, will give some idea of the display:—

	Height.	Weight.		No. of Wires.
A. Pole for angles	9 metres	34½	...	30
B. Pole for line	7·50 „	44	...	30
C. „	9 „	16	...	30
D. „	7·50 „	16	...	30
E. „	6 „	7½	...	1 to 8
F. „	5 „	6½	...	1 to 8
G. „	6 „	6½	...	1 to 4
H. „	6 „	5	...	1 to 4
I. „	5 „	5	...	1 to 4
J. „	5 „	3·65	...	1 to 4

M. Desgoffe shows specimens of poles to be used at the crossing of rivers 25 metres in height, and over a thousand kilogrammes in weight.

Some poles are so constructed that the wires are placed in the interior, some are fitted with boxes for testing purposes, and some are arranged to connect subterranean with aerial lines, the terminals being in a box fitted to the hollow post, at such a height as to be easily accessible. Altogether, the display of iron posts is one of the best exhibits. The poles wanted by the *Scientific American*, made of iron strips wound spirally, are to be seen here; but, still, improvements can be suggested; and, as we are day by day perfecting our steel working machinery, it will not be long ere iron gives way, to a certain extent, to steel, and, instead of the iron poles, we may see lighter and stronger poles, made of strips of steel wound spirally.

On entering the annexe, and turning to the left, we first notice the instruments shown by M. Hardy, of 6, Avenue de Lamotte, the principle of which are a registering anemometer and a Meyer's apparatus for multiplex transmission. We shall have to refer to Meyer's instrument again, for there are several in the Exhibition, and there is nothing new in the anemometer. We now come to the display of MM. Breguet, of 39, Quai de l'Horloge. This firm is probably almost the first, if, indeed, it is not the first, in France for the construction of electrical apparatus. The workshops in the Boulevard Montparnasse are well worth a visit, as much more information can be obtained from seeing the instruments in the various stages of manufacture than when viewing them in the complete state, but separated from them by a rail, and coolly informed by a dignitary in uniform that you must not take sketches. However, in our case, as in the case of most Englishmen, we should imagine, the "must not" simply ended in "we will." Friends informed us that in some cases the sketches had been taken away and torn up by those in authority. If this occurs frequently, exhibitions, instead of conferring a benefit, will be looked upon with disgust. The value of an exhibition is in allowing a comparison of progress to be made from time to time, and an engineer thoroughly conversant with a machine, if he desires to plagiarise, will not care whether he be allowed to sketch or not on the spot; if he be worthy his profession, he will be able to carry away in his mind the modifications he wants to reproduce, and sketch them out in his own rooms. This is a digression, but we have wished to say these few words on the subject of placing difficulties in the way of students.

The exhibit of MM. Breguet is very general—Batteries and materials for batteries, portable cases of telegraph engineering tools, specimens of electric bells, Breguet's alphabetical telegraph apparatus, Guillot's magnetic electric manipulator, telephones of various designs, two small Gramme machines, &c. In the section devoted to instruments of precision we find this firm again exhibiting. A short visit to Montparnasse enabled us to see some experiments with Planté's secondary battery which we referred to in our issue of June 29. The battery consisted of ten of the secondary cells, and had been charged from four of Thomson's tray cells. A platinum wire 20½in. by ·3m. diameter was rendered incandescent, and continued so for a considerable time. Unfortunately, we did not obtain the exact time, as we were interested in noting the exceedingly neat contrivance for changing the current from one of tension to one of quantity, and in seeing iron wire burned. The experiments, however, could not have lasted less than half an hour, and, as several had been made before our arrival, we do not hesitate to say that Planté's battery deserves careful attention.

[TO BE CONTINUED.]

GENERAL CONSIDERATIONS UPON TELEGRAPHIC TARIFFS.*

[CONTINUED FROM P. 189.]

Let us endeavour to formulate briefly the eight solutions to which this study has led us:—

I. Governmental monopoly is justified when it is applied to a public service which ought to be placed within the reach of the greatest number, and, therefore, should be extended to places where, and at hours when the traffic is heavy. It ought to cease when private enterprise is disposed to undertake the service in certain localities or specialities which the Government does not feel called upon to serve.

II. The said monopoly is a cause of cheapness, because it can subordinate to the general interest every consideration of profit, and because an assured traffic permits it to work advantageously.

Competition tends, on the contrary, to the raising of tariffs, because the purchase or fusion of the rival enterprises renders the working more onerous and increases the net cost.

III. Enterprises to which governmental monopoly cannot be extended *(international submarine lines)* ought to be the object of a conditional monopoly, so as to shelter the public and enterprisers from the disadvantages of unlimited competition by fixing a maximum return beyond which the profits should benefit the public in the form of reduced rates or improved service.

IV. The effects of a reduction of tariff in the most favourable conditions (the interior service of a country) are the maintenance of the gross receipts by the stimulation of cheapness, and in ordinary conditions the diminution of the gross revenue, this stimulation being insufficient, above all, in international relations, to compensate the reduction of the mean product per unit. In both cases, and without known exception, the net product is diminished.

[There is sometimes advantage in translating by approximate figures these results of the experience of the past; when, for example, one wishes to estimate the progress and the *probable* gross receipts of the year or period which follows a reduction, or, as the case may be, an increase of tariff. We are able to recommend the following method:—Increase the movement of the correspondences from the last year or known period after the mean increase, which is produced in the latter place, from year to year, in cases where the tariff has not changed, and thus obtain the probable traffic on the hypothesis of the maintenance of the existing tax. Work out then, upon the supposed movement, an increase or decrease proportionate to the reduction or increase of tariff projected. In a given country where business and correspondence are active one can admit that the increase or decrease will be approximately that which is necessary to reproduce the calculated gross receipts without change of tariff. In active international relations, notably at short distances, the effect of the modification of tariff is about *half* of what is needed to reproduce the same gross receipts. These probabilities furnish only limited results. It is essential to complete them by estimating the increase or decrease of expense, according to circumstances.]

V. As a general principle, the working, even by the State, should cover its expenses. An exception to this rule may be made in the public interest when indirect advantages benefiting the majority are considered sufficient compensation.

VI. A certain profit is desirable, to encourage and develope private enterprises, and, in the case of working by the State, to allow the Governments to realise without apprehension the progress which the service demands. But it is advisable that the profit be limited according to circumstances, and obtained by means of tariffs not so high as to retard the growth of the traffic.

VII. The charges paid by the public ought not to be proportionate to the net cost when the interest of the majority demands that it be lowered below this proportion; but the net cost may be usefully sought as a base for the division of the rates between the offices concerned.

VIII. The uniform tax, and, still further, the unique rate, are of convenient application; but, for a large territory, or for a section comprising several offices, it becomes at once ruinous for the administration and onerous for near communications.

If it is true, in the case of letters, that the service rendered has nearly the same value, whatever the distance may be, one cannot say the same of telegrams, of which the value to correspondents is much greater at a long distance.

[TO BE CONTINUED.]

* Translated from the *Journal Télégraphique*.

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THE ELECTRICIAN.

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All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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NOTICE TO EDITORS.

We shall be happy to exchange with the Editors of Scientific journals who receive the first numbers of THE ELECTRICIAN.

Nous serons heureux de faire l'échange avec Messieurs les Rédacteurs des Journaux scientifiques qui recevront les premiers numéros de L'ELECTRICIAN.

Es wird uns ein Vergnügen sein mit den löblichen Redactionen der deutschen und anderen continentalen Journäle und Zeitschriften, denen die ersten Nos. des ELECTRICIAN *zu Händen kommen möchten auszutauschen.*

I Signori Editori di giornali scientifici che riceveranno i primi numeri dell' ELECTRICIAN *ci faranno cosa gradita accettando il cambio che loro offriamo.*

NOTICE.

REPRINT OF NO. 2.—Numerous inquiries having been made for our second number, the edition of which was exhausted, we beg to inform our readers and the trade that No. 2 is being reprinted, and will be ready next week.

DOES GOVERNMENT MONOPOLY RETARD INVENTIONS?

The question here proposed is one which we should prefer to see calmly discussed before attempting to give a definite answer. There are and always must be two sides to every question, and, in the case we have to consider, we have, on the one side, the inventor, and, on the other, the Government officials. The former believes his work is calculated to supersede everything that has been done previously, and that his invention should be adopted because he says, and is ready to prove—to his own satisfaction—that it is all he believes it to be. A man is good for nothing unless he has faith in himself, in his own capabilities, in his own work; but there is such a thing as believing too much in oneself, and being utterly unable to receive a candid opinion or acknowledge a proof from an outside source. Of the various classes into which the human race has been divided, we fancy the genus inventor is the one which believes in self to the greatest extent. It must not be supposed that in saying this we wish to disparage inventors. Not so; we simply wish to indicate that their standpoint is not always a safe one, inasmuch as it presents only the brightest side of the question. There is almost as great a danger of going to the opposite extreme, and by means of figures showing that only one out of so many inventions bears fruit, and that, therefore, the officials are wise in rejecting every invention brought before them.

The rule of the Telegraph Department seems to be—prove the value of your invention at your own expense, and then we may think of adopting it. It must, however, be considered that an inventor is not always a rich man, nor can he always induce those who have money to assist him. Is it not a notorious fact that the majority of the most valuable inventions, in the paying point of view, are not credited to the real discoverers, but have come by various means into the hands of those whose names are now associated with them, and who have reaped the benefit of the unknown persons' labour? The philanthropic capitalist to assist the poor inventor must be carefully sought for before he is found, and such a *rara avis* is he that as yet we have never heard of anyone finding him. The promoter who advances money generally takes the giant's share to the detriment of the man who finds the brains. But, supposing the difficulty of expense to be overcome, can the inventor be sure of due consideration for his bantling? The discoverer of a new invention is the best person to bring out its peculiarities, and in electrical work many of the instruments are of so delicate construction, and require so much care, that anything new sent to the authorities for trial can hardly be used as it should be. We do not for a moment suppose that wilful obstruction to success would be made; but it is extremely doubtful if that amount of patience would be shown, or care taken to remedy a simple defect, which might render the trial of the invention satisfactory, by men who say the work is at present done better than any other nation does it, and, therefore, it will be time enough to trouble about upsetting routine and introducing new things when we begin to be unable to grapple with our work.

In considering the question of monopoly in telegraphs, how are we to reconcile these conflicting interests? In the first place, we must have specific charges, and no general condemnation. These, however, we are beginning to accumulate. At the commencement of the year Dr. Siemens, in his presidential address to the Society of Telegraph Engineers, dwelt somewhat on this question, but only in general terms. He said, "I incline to the belief that the open competition for public favour does act as a powerful stimulant to invention in the United States, a stimulant which was equally active in this country in producing a variety of novel instruments at the time prior to the purchase of the telegraphs by the Government." He also pointed out that this country still takes the lead in submarine work, and attributed it to the fact that here competition is in full activity. Since then, from time to time, similar statements have been made, general but not specific. Mr. W. H. Preece, at the late meeting of the British Association at Dublin, read a paper with the evident intention of showing the groundlessness of these charges. His statements were combated by Mr. Graham Bell and others in the discussion which immediately followed the reading of the paper, and we give in our issue to-day two papers which have appeared in the *Society of Arts Journal*, one of which brings a specific charge, while the other criticises the correctness of Mr. Preece's statements. Whether Mr. Bell or Mr. Herring has made out a case is to us doubtful. It is necessary to understand what Mr. Bell wanted before we can decide upon his case. He has often admitted that he is not a professed electrician, and when he brought a somewhat crude idea, for it can hardly be said to be more, of a multiple system to the notice of the authorities, we suppose he desired them to take up and work out his idea. The result of his work has been the telephone, which, if we may credit American writers, is not his, but a mixture of Bell, Dolbear, and Gray.

Will anyone argue that the authorities did wrong in this

special case? The second, that of Mr. Herring, is much more complicated. Not only does he accuse the authorities of retarding progress, but he accuses them of wilfully placing obstacles in the way of inventors. The questions his letter raises are far too grave to be discussed from an *ex parte* statement, and as, no doubt, some of the authorities implicated will answer his letter, we shall reserve consideration of it for the future. Meanwhile, progress is being made in the right direction, namely, that which we have previously indicated—the bringing of specific charges; and we would advise all those who have or think they have a case against the monopoly system to clearly set forth their charge and their views upon the subject. We have our own opinions as to certain changes that might be made beneficially to the working of the Telegraph Department, to inventors, and to the public at large. One of these is that so much time should not be lost before adopting more extensively those improvements that have been thoroughly tested and are proved to work satisfactorily. We may instance, as cases to the point, the introduction of duplex and quadruplex working. It is only now that the quadruplex system is being adopted to any extent. Perhaps, however, it may be urged that there are advantages in not being in too great a hurry, and that, by exercising a little patience, a more perfect machine is ultimately used than would otherwise be the case. We hope it is so, but fear, with all our patience, that the best is not always obtained. We notice, for example, that certain sounders of Mr. Elisha Gray's design are to be introduced into England. Care should be taken that the best design should be adopted, but we have heard that another has been chosen. Concerning the Telegraph Department and inventors, as usual, the fact is, no doubt, that "much might be said on both sides;" and we are fain to exercise a little more patience, and wait for further information before assenting to a verdict of condemnation.

ON THE STUDY OF ELECTRICITY AS A PROFESSIONAL PURSUIT.

BY THOMAS T. P. BRUCE WARREN.

[CONTINUED FROM P. 176.]

In directing the attention of the electrical student to such portions of chemical research having a direct bearing on telegraphy, I feel that I ought not to omit to mention the very important experiments made a few years ago by the late Dr. Matthiessen.

As far back as 1858 Sir William Thomson found that there was a great difference in the specific conductivity of copper wire. Writers on toxicology—as Taylor, Orfila, Reinsch, and others—had previously pointed out that the effect of arsenic on copper was so marked that it was at one time proposed to use the electrical indication in cases of suspected poisoning.

Copper containing large quantities of arsenic is too brittle to be drawn into wire at all; whilst small quantities were found to modify its conductivity to such an extent that manufacturers were soon persuaded that arseniferous ores could not be used for telegraph purposes.

The production of high-conductivity copper was for a little time the monopoly of one manufacturer; it can now be had from three or four firms. Rio Tinto copper is found to be superior to the metal obtained from English ores, the Swansea being the best obtained in this country.

The influence of arsenic on copper is so remarkable that, if the two are melted or worked near each other, without being brought into contact at all, intentionally, the copper will be found to have suffered in its conductivity, although the amount of arsenic absorbed by it is so small that its determination requires very careful manipulation.

The impurities found in wire for telegraph cables are so small that it requires the utmost caution and skill to arrive at trustworthy results in the chemical testing of copper wire.

I believe that it is not generally known that the soiling of the surface of copper wire has a marked effect on its conductivity.

A few years ago I discovered that a copper wire coated with an alloy of tin, lead, and bismuth, had its conductivity increased from one to two per cent. An occasion arose which led to the testing of this wire by Sir William Thomson, who was so surprised at the result that he requested a length of wire to be taken and tinned with this alloy for one-half of its length, the other half being left plain, so that every chance of the experiment being made on the same wire was rendered visible.

The wire was of the soft annealed description, so that it can hardly be considered that the test in tinning had anything to do with it. As a test of this, I had a wire passed through the machine and empty tinning trough, kept at the same temperature; no difference was found between this and the wire which had not been submitted to this process.

I attributed this effect to the reducing action of the lead and tin in clearing the surface of the wire. De la Rive,* however, many years previous to this, stated that copper, soiled only by handling, had its conductivity improved by igniting.

Even practical electricians may say that this is carrying the matter to a degree of nicety suitable only for research.

I can assure the reader that, with proper care, and a battery capable of yielding a "large quantity current," no difficulty whatever will be found in recognising these effects.

The arrangement given in the first number of this journal will show its effect most unmistakeably. The apparatus with which I made my first observations was an ordinary divided metre wire bridge, as figured in the same paper.

Ordinary telegraph copper usually gives from 99·5 to 99·95 per cent. pure copper.

Valuable as are the researches of the late Dr. Matthiessen, I cannot help thinking that a very important part of the inquiry as to the permanency of alloys was omitted; and this omission is more strongly impressed upon us when we consider the singular results which now and again are met with in fine drawn wires of the platinum silver alloy. For the production of electrical standards of resistance, economy is not the predominant consideration, so that probably the defects found in fine wires will not be met with in wires of larger diameter.

Some time ago Sir William Thomson suggested that in the construction of resistance coils no wire should be used with so small a diameter as to reduce its length to less than four or five metres for higher resistances, or 1,000 units. This was, I believe, to obviate or reduce the heating effect, since the greater the mass the less the heating effect. This suggestion has to my mind a far more important value in another direction.

Chemists are well aware that alloys suffer important changes by hammering and stamping, so that if a chemist were requested to analyse a silver or gold coin he would take portions from different parts of the coin. Mechanical action actually causes the squeezing out of the constituents of an alloy, so that the coin is by no means homogeneous in its constitution, but contains a variable amount of the normal alloy with a greater or less amount of the metal thus separated, the central portion being more nearly of uniform composition.

It would be a very interesting inquiry if some one would follow this matter up on alloys used for electrical resistance. There is no reason for believing that platinum silver would be free from this separation under similar treatment. We may, however, predict that the nearer the constituents of an alloy approach each other in their physical qualities as hardness and density, fusibility, &c., the less would be the chance of this separation of the metals. The drawing process, by which wires are reduced to different degrees of fineness, is adapted for effecting this separation more completely than any other treatment to which alloys are subjected. The discussion which arose on the material for the construction of standards of electrical resistance, and which appeared in the *Philosophical Magazine*, must have struck the mind of any chemist with an impartial feeling in the matter as unworthy of the time and material spent upon it. My own impression is that a pure metal must be best for permanence, and not a single fact was adduced to show that mercury, as proposed by Siemens, had more than an imaginary defect.

With mercury we entail no changes in hardness, &c., from drawing or annealing, which must of necessity occur with every other metal; we have no liability to a crystalline structure, or whatever may be the changes going on in alloys; and such facts, in favour of the homogeneous nature of this metal, ought to have silenced everything savouring of prejudice.

No one who has had any experience with india-rubber wires, in which the copper conductors are coated with tin or an alloy of tin and lead, would, I venture to say, attempt to deny that such conductors do become more or less brittle.

Mr. R. S. Culley was the first, I believe, who noticed this fact, and I must confess that at one time I thought this statement

* "Treatise on Electricity," trans. by C. V. Walker.

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arose from prejudice. I am able to endorse his opinion from a very long experience with tinned wires. As these wires were generally vulcanised, I thought this change might be due to the action of sulphur; but, as the same change takes place in the wire when heated for the same time without sulphur, it is not impossible that the heating may be instrumental in producing this change.

I think that, from what has been pointed out in the few preceding paragraphs, it will assist us in comprehending more fully the reasons why clearing the surfaces of wire by some chemical process improves its conductivity. We have only to imagine that, in drawing copper wires, we produce the separation of its impurities, which will be squeezed to the surface from their lighter specific gravities, &c. These impurities consist principally of cuprous oxide, sulphur, silica, &c., which are either reduced by more easily oxidisable metals or removed altogether. The fact, too, that small wires have a higher conductivity than larger wires may also receive an explanation in this tendency of the impurities being separated by repeated drawing. Whilst on this subject it may be worth while to refer to the singular effects of carbon, phosphorus, oxygen, and sulphur, on the conductivity of copper wire. According to Dr. Matthiessen's experiments, the effects of these substances were something almost magical. Now, if we act on the surface of a copper wire with any of these substances, the difference in conductivity, though certainly visible, may be said, in a general sense, to be almost imperceptible. Even arsenic deposited on copper wire by Reinsch's method of testing fluids suspected of containing arsenic will give a similarly curious contradiction to Matthiessen's statement. The only way in which I can see any solution to the enigma is that, when these substances are incorporated with copper wire, and consequently arranged, so to speak, as lumps of opposition, or high resistance to a current, the copper at the particular spots becomes attenuated. If these impurities are removed to the surface of the wire, or if the surface of the wire be acted upon by any of these substances, we cannot possibly obtain the same lowering in the conductivity, even if we go so far as to destroy a much larger quantity of copper to produce the corresponding amount of impurity existing in the specimen operated on by Dr. Matthiessen. On this particular point much information is needed. We can only hope to see a due recognition of the assistance which chemistry may bring to telegraphy or electricity when electricians will make up their minds to include chemistry amongst their studies.

It reflects little to the credit of our chemical knowledge as electricians when we consider that our information on india rubber and gutta percha, which are among the most important derivations from the vegetable kingdom, can be given in perhaps fewer words than would suffice for some outlandish organic substance, and of which a few shillings would suffice to buy all that may be contained in the world.

The separation and estimation of copper in a tinned conductor may be required by the electrician. The following method will give good results.

Boil the wire in nitric acid (S. G. 1·13) by which the copper and lead will be converted into soluble salts, whilst the tin will be found oxidized into stannic oxide, which can be filtered from the liquid after proper dilution, and weighed.

The filtrate is now boiled with a large excess of sulphuric acid, until every trace of nitric acid is driven off; the solution properly diluted with water will deposit the lead as sulphate, from the weight of which the lead can be estimated.

The liquid filtered from the lead sulphate contains the copper, the amount of which may be obtained by titrating with stannous chloride, or, if greater accuracy is required, by precipitating the acid solution with sulphuretted hydrogen, and heating the sulphide so obtained in a current of dry hydrogen as previously given.

This is necessary, as a very faint trace of iron may be present, as well as a little zinc. These metals, if present, will be found in the filtrate from the sulphide of copper. The liquid is well boiled to expel all traces of sulphuretted hydrogen, and, when cool, strong liquid ammonia is added in excess, and allowed to stand in a warm place until the peroxide of iron has settled. The liquid filtered off will contain the zinc which can be precipitated with ammonium sulphide.

The electrician will, as a rule, find sufficiently clear instructions for the manipulation and treatment of substances to be analysed in most chemical works. One very notable exception, at any rate for one who is working without the assistance of a tutor, is the treatment of metallic sulphides by Rose's method. I have, therefore, given the precautions which in practice I have found necessary. Most metallic sulphides may be heated for a long time if the heat is not too strong, but during the intense heating which is necessary at the end of the operation great judgment is required. Even the remarks given by Fresenius will lead to very disappointing results in the treatment, more especially of zinc sulphide.

[TO BE CONTINUED.]

THE BRITISH ASSOCIATION.

SECTION A.—MATHEMATICAL AND PHYSICAL.

A New Determination of the Number of Electrostatic Units in the Electromagnetic Unit. (Telegram and letter to Sir William Thomson from Prof. W. E. Ayrton.)

The Red Sea, August 3, 1878.

From Singapore I sent you the following telegram on July 13:—

"Kindly inform British Association that air condenser measured magnetically and statically gives mean value ratio of these units (29·80) twenty-nine point eight nought ohms.; Foucault's velocity light."

In the autumn of this year I propose communicating a full account of this investigation to the Physical Society or the Society of Telegraph Engineers, or otherwise as you may advise; but I thought that as the British Association Committee had for so long busied itself with the determination of electrical units you might deem the result of this investigation of Mr. Perry and myself worthy of a preliminary notice at the meeting of this association to be held this year at Dublin. Not being sure that I should arrive in Europe in time to reach Dublin at the commencement of the meeting, although I hope to be present during the last three or four days, I took the liberty of sending you the telegram quoted above.

The result we have obtained for v is the more interesting, inasmuch as without any bias being given to any one of our experiments, the mean value is identically the same as that obtained by M. Foucault for the velocity of light, whereas all previous determinations of the number of electrostatic units in an electro-magnetic unit have led to results differing considerably from Foucault's velocity.

It appeared to Mr. Perry and myself that the method best suited for the accurate determination of v consisted in measuring the capacity of an air-condenser (1), electromagnetically by the swing of the needle of a ballistic galvanometer; and (2) electrostatically by a measurement of the linear dimensions of the condenser, since the equation connecting these capacities

$$s = v^2 S$$

s being the absolute electrostatic capacity
S „ electromagnetic „

leads to an equation involving only the *square root* of a resistance.

Two difficulties of course presented themselves in this investigation, difficulties that it took us many months to overcome, labouring as we were under the disadvantage of experimenting in a country like Japan. They were—

(1). To obtain a large air condenser of which the plates had sufficiently true surfaces that the electrostatic capacity could be accurately measured; at any rate when the plates were not nearer than half a centimetre to one another.

(2) To obtain a galvanometric arrangement of sufficient sensibility to measure the small capacity of such an air condenser and sufficiently ballistic that the air damping should be almost inappreciable.

A full description of the condenser we employed (and which had a guard ring, and all the different arrangements we could think of for obtaining accurate results) will accompany the account of the investigation to which I have referred. It is sufficient here to mention that the errors arising from the surfaces of the condenser plates not being true planes were practically eliminated by capacity experiments being made with successive adjustments of the condenser plates, a different set of points in the upper plate being each time brought to the fixed distance from the lower plate.

The arrangement of a ballistic galvanometer to fulfil the two conditions mentioned in (2) was very troublesome. I made several astatic needles, none of which satisfied us, and we were beginning to fear my departure from Japan would necessitate the abandoning of the investigation. At last, however, an astatic combination, containing forty small magnets (and of which a description will accompany the paper), gave satisfactory results, and I obtained three excellent sets of observations on June 18, June 23, and June 25, when my departure put an end to further investigation. The *mean* values obtained for v on each of these three days were—

29·74 ohms,	June 18
29·95 „	„ 23
29·72 „	„ 25

Final mean 29·80

It will be observed that the greatest difference between any one of the three daily means and the final mean, is only about half per cent. The final mean 29·80 million metres per second (and which represents the mean of ninety-eight discharges of the air-condenser) may, I think, be regarded as correct to, at any rate one per cent., and is exactly equal to M. Foucault's velocity of light.

In the astatic combinations I employed prior to June 18 I used eight needles, and weighted the lower set of needles with pieces of brass, so as to give it a barrel shape, but the results were unsatisfactory, as there was either not sufficient delicacy or else too much damping. Consequently all the numbers obtained prior to June 18 have been abandoned. On June 18 were made the first set of experiments with the forty-magnet astatic combination, the idea of this arrangement being to make an approximately spherical mass of little magnets all slightly separated from one another, and all previously magnetised to saturation. As it would have been too difficult to make this entire sphere all of magnets I finished it off with segments cut from a little wooden sphere. But the half Napierian logarithmic decrement was 0·12095, and we thought this too high. Consequently, in the interval from June 18 to June 23, I took this astatic combination down, and replaced the segments of the wooden sphere by segments of a small leaden hemispherical *shell*. This diminished the half Napierian logarithmic decrement to 0·07825, and with a periodic time of 39·5 seconds I obtained most consistent results. But on the other hand the close agreement of the results obtained on June 18 and on June 25 leads one to conclude that the wooden segments were quite satisfactory, and that replacing them with the leaden shell was unnecessary.

The table at the end of this letter gives the value of the most important constants employed. The battery consisted of 382 perfectly new Daniell's cells in series, and the galvanometer had a resistance of 20,000 ohms. All resistances were compared with a new German silver wire box recently received from Messrs. Elliott, London.

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The values obtained for v are (as far as I am aware), up to the present time, as follows :—

MM. Weber and Kohlrausch	31·074	ohms.
Sir W. Thomson	28·2	„
Prof. Clerk Maxwell	28·8	„
Professors Ayrton and Perry	29·80	„
Velocity of Light, M. Foucault	29·8	„

During the last twelve months we have been hard at work with the determination of the electromotive force of contact of metals and liquids, using a new apparatus. Some of the results are, we venture to think, most interesting—for instance, the electromotive force of contact of hot and cold mercury, *no other conductors being in contact with either mercury;* the electromotive force of contact of a cold metal and hot mercury, no third conductor being in contact with either, &c. The determination of the electromotive force of contact of the pairs of constituents of Mr. Latimer Clark's constant mercurous sulphate cell was most laborious, and occupied me weeks, in consequence of the difference of potential that exists between the body of the mercurous sulphate paste and the layer of water that floats on the surface. However, a forlorn hope kept me hard at it, and I am glad to say, at last, I was successful in getting good results. We have gone over all the old ground that furnished the basis of our former paper, as well as much new ground.

Determination of the Number of Electrostatic Units in an Electro-magnetic one.

Date.	Area of condenser plate in square centimetres.	Distance between the plates in centimetres.	Weight of the astatic combination in grammes.	Periodic time in seconds.	Half the Napierian logarithmic decrement.	Mean value of v.	Remarks.
June 18	1324·96	1·024	2·15	25·3	0·12095	29·74	Ninety-eight discharges of the air-condenser.
„ 23	1323·14	0·7728	3·4	39·5	0·07825	29·95	
„ 25	1323·14	0·7728	3·4	42·2	0·081865	29·72	

The distance between the upper condenser plate and the guard ring was slightly increased by diminishing the size of the plate to avoid the possibility of loss of electricity.

June 18.—The lower set of needles was weighted with segments cut from a small wooden sphere.

June 23 and after.—The lower set of needles was weighted with segments cut from a small leaden spherical shell.

Number of magnets in astatic combination 40.

Number of new Daniell's cells in series 382.

RECENT OBSTRUCTIONS IN TELEGRAPHY.*

The interesting paper read by Mr. Preece at the meeting of the British Association, at Dublin, is very liable to promote misconception as to the influence of the Telegraph Department upon telegraphic invention. At the commencement of his paper, Mr. Preece says that "it has been publicly stated by very high authorities that, since the transfer of the telegraphs to the State, invention in that art has left the shores of the United Kingdom and flown to those of America. Moreover, it has been intimated that the monopoly in telegraphy possessed by the State has checked improvement. Such statements are made in ignorance of the facts. Invention has not left the shores of England. The English Telegraph Department stands in the first rank. No one has ever been heard to complain of the action of the Post-office in adopting improvements, but, perhaps, some disappointed inventor." Probably Mr. Preece is right in the assertion that no one complains of the action of the Telegraph Department of the Post-office except disappointed inventors. This, indeed, as I understand the question, is all that the authorities, and others to whom Mr. Preece refers, have felt it needful to insist upon. Of course it is absurd to claim, as Mr. Preece does when speaking of telegraphic invention, that "the English Telegraph Department stands in the first rank." He mentions the most prominent telegraph inventors, and the principal telegraph inventions, but he does not, and cannot claim anyone of the former as connected with the Department, or of the latter as emanating from it. In fact, the claims put forth by Mr. Preece were completely negatived in the course of the discussion which followed the reading of his paper. Mr. Bell, the inventor of the telephone, said, "he wished to call attention to one or two points. Mr. Preece had said that the Government control had not tended to hinder invention in this country. His personal experience of Government control had been this. In the beginning of the year 1874 he invented in America a system of multiple telegraphy, by which 16 or 20 messages might be sent simultaneously on a single wire, and this this was submitted by him to the Telegraph Department of the British Government. In reply to his request for an investigation he received a printed paper, such as probably was sent out to every inventor who applied to the Postal Department. It stated that the Post-office Department would take into consideration the invention submitted at the expense of the inventor, and that in the event of the improvement in telegraphy being thought worthy to be adopted by the Government, the question of remuneration would be left entirely to the Postmaster-General. It was that reply which induced him to bring forward his invention in America. He brought his system of multiple telegraphy before the telegraph world in America, and the outcome had been the telephone. He should be the last man to say that Government control was not necessary in this country for the sending of telegraphic messages for public use. Still, he believed Government control to be destructive of invention."

My own experience of the Postal Telegraph Department coincides with that of Mr. Bell. Indeed, my experience having been gained during a negotiation with the Department which has lasted for more than seven years, entirely supports the views which have been expressed in opposition to Mr. Preece's statements. A short time since I was advised that, as I had a strong case against a public department, it was my duty and my privilege to lay it before the Queen, with the consent of the Secretary of State, in the form of a memorial, and on the 28th of June, 1877, I received the following acknowledgment from Whitehall :—

"SIR : I am directed by Mr. Secretary Cross to inform you that he has laid before the Queen the petition which accompanied your letter of the 19th inst., and that it has been referred by Her Majesty's command to the Postmaster-General, to whom all further communications on the subject to which it relates should be addressed.—I am, sir, your obedient servant,

"Mr. Richard Herring." "A. F. O. LIDDELL.

On the 25th of December last I wrote to the Postmaster-General, reminding him that my petition, which the Secretary of State informed me six months previously Her Majesty had graciously referred to his Lordship, had not received any attention. The receipt of this letter was simply acknowledged on behalf of Lord John Manners, by Mr. Parkhurst, the chief clerk of the Post-office, to whom I wrote the same day, as follows :— "Surely it cannot be right when a subject has exercised his constitutional privilege of petitioning the Queen, with the approval of the Secretary of State, and when the Sovereign has been graciously pleased to remit such petition for the careful consideration of one of her Ministers, for the Sovereign's commands to be treated with contempt? Kindly consider this matter, and let me have your views."

No reply, however, to either communication has been sent to me by the the authorities of the Post-office. The substance of my petition was as follows :—

Shortly after the acquisition of the telegraphs by the Government, I was informed that the various efforts which had been made to print the telegraph alphabet by definite signs had utterly failed, and that in consequence of the frequent errors arising from what is known as the Morse system, the authorities of the Post-office had determined, if possible, to obtain some other and more definite method.

In consequence of this information I brought my system under the notice of the authorities of the Post-office, but the engineer-in-chief of the Telegraph Department condemned the invention because the telegraph signs by my system were printed ; and he informed me that it was a *sine qua non* that the signs should be embossed. To emboss telegraph signs vertically on a narrow strip of paper at the same time that the paper receiving the signs was being unwound and carried forward by clockwork, occasioned no little difficulty. To make and break a longitudinal mark drawn on the paper slip by the Morse system was a very easy matter indeed compared with the suggestion to emboss definite telegraph signs vertically while the paper was running, and with as much distinctness as would be required to form a book for the blind. This difficulty, however, I succeeded in overcoming, and on the 30th January, 1871, an inspector was sent from the General Post-office to examine and report upon my instrument. On seeing it he at once condemned it because it was an embosser and did not print. I then wrote to the Secretary of the Post-office, stating that my first model had been objected to because it did not emboss ; and that the second model had been condemned because it did emboss, and I asked him to be good enough to inform me whether the department preferred printed or embossed telegraph signs. The Secretary replied :—" February 6th, 1871.—There is no intention on the part of the department to revert to embossing processes."

An official copy of minutes and correspondence, which is in print, has the following remark addressed by the Engineer-in-Chief to the Secretary of the Post-office, prior to the date of the letter which I have just quoted. "Of course, even though there is no doubt Mr. Herring's invention is useless, I will have it seen." And shortly afterwards, 18th April, 1871, the Engineer suggests to the Secretary in a fresh minute, "we might allow Mr. Herring to try his instrument on a line where it would no doubt die a natural death." Of course I was not content that my instrument should be tried on any such line ; and, on the 18th of the following month, the Secretary of the General Post-office wrote to me, "that my system was much superior to the numerous methods which have been brought forward from time to time during the last twenty years." And shortly afterwards he wrote to me, and proposed that my instrument should be fairly tried by Sir William Thomson and Professor Jenkin, thus ignoring the opinion of the Engineer-in-Chief altogether, who in one of his official minutes had actually reported that it was "impossible to produce readable signs" by my instrument, and that the instrument was "practically worthless."

The proposal, however, for a full and fair trial of the invention which the Secretary of the Post Office suggested, was couched in terms to which considerable objection might have been taken by me. For instance, the Secretary proposed that while the trial was pending the Department, "even (said he) if it forms an adverse opinion with regard to your instrument, will abstain from expressing that opinion," and therefore, he added, "the Department would expect me to abstain from publishing *ex parte* statements." Thus he proposed a trial of my instrument by scientific persons as a guide to the judgment of the Department, and yet he admitted that the Department was capable of allowing itself to form an adverse opinion with regard to that instrument while the trial was pending. The arrangement of the terms of reference was next proceeded with. The terms of reference required as follows :—" It will be desirable that you (Sir William Thomson and Professor Jenkin) should test the wire which is to be used before Mr. Herring's instruments are put on it, and that you should satisfy yourselves that the insulation of the wire is effective." And further, "the instrument is not to be condemned or reported against for any mere flaw or accidental hitch in the working as distinguished from faults, if any, in the system, and any fault of detail is to be reported to Mr. Herring, to give him an opportunity of overcoming it before you finally report on the merits of the instrument."

The proposed trial of the instrument was commenced by Messrs. Thomson and Jenkin at the Central Telegraph-office, in the month of October, 1872, but as I observed a manifest want of attention on their part to the terms of the reference, I called on the Secretary at the Post Office, and detailed the grounds of my objection to any report being written unless the terms of the reference were heeded, and the trial of the instrument conducted accordingly. I afterwards called on my solicitor, and handed to him a memorandum of what had passed between me and the Secretary. This memorandum was forwarded to the Post Office by my solicitor, and the Secretary wrote acknowledging it to be "accurate as far as it goes." After all this had taken place, however, a report was actually made and

* From the "Society of Arts Journal"

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signed by Messrs. Thomson and Jenkin without proper trial, although the Secretary of the Post-office had admitted that further trial was necessary.

In accordance with the terms of the reference, which required that the instrument should not be reported against for any accidental hitch in the working, but that such should be first reported to me, in order that I might have an opportunity of overcoming it before a final report was made, the referees informed me preliminarily, in writing, that some of the symbols received by my instrument were imperfect; but, they added, that they thought it might have arisen from the "rapid and somewhat jerky style of keying practised by the telegraph clerks." This, in fact, was the case. The referees added, in the preliminary report from which I am now quoting, "It is very desirable that an automatic sender should be arranged to send slips with actual messages, so that they may be recorded by Mr. Herring's instrument, as no trials can be quite satisfactory which do not exclude the imperfections of sending." With reference to this suggestion, a special minute, penned by the Secretary of the Post-office, and dated November 18th, 1872, may be seen amongst the papers officially printed. It is as follows:—

"Write to Mr. Fleeming Jenkin with reference to his preliminary report on Mr. Herring's telegraph instrument, and request to be informed whether he is still of opinion that the Department should make, at its own cost, an automatic sender for the purpose of further testing Mr. Herring's instrument." To which Mr. Fleeming Jenkin replied:—"In answer to your letter of the 18th instant, I beg leave to say, that I think it unnecessary that an automatic sender should be made by the Department, unless the officers of the Department think it desirable." Of course this letter of Professor Jenkin is utterly inconsistent with the rules which govern the conduct of referees, and with the ordinary principles of justice. It comes, in fact, to this, that one of the referees writes to one of the parties to the reference to inquire whether that party thinks it "desirable" that a step should be taken which the referee had previously declared "very desirable" for a satisfactory trial. In effect, the referee applies to one of the parties for directions as to the method of proceeding in the reference. A reference thus conducted would be an absurdity, and its results must be nugatory, and, accordingly, the Secretary admitted that something more would be necessary to a satisfactory trial, and within a month of his correspondence with Professor Jenkin, he gave his consent in writing for a further trial. It is unnecessary for me to analyse the report which Sir William Thomson and Professor Jenkin undoubtedly signed, and for which they were paid enormously by the Post-office, although the Secretary knew at the time that such report was based upon no proper trial, and that he had even given his consent in writing for a fresh trial on the terms of the reference. When, however, the report appeared, I dealt with it and forwarded my remarks to the Secretary of the Post-office. Indeed, Messrs. Longmans published the eport with my remarks in parallel columns.

The claims which I make for greater speed, greater accuracy, and greater economy, are all sustained by that report when it is read by the light of the comments which I have appended to it, and it is interesting to contrast that report with the opinions of the scientific advisers of the Post-office at the outset of the discussion, when they denounced my instrument as "practically worthless," and stated that it was "impossible to produce readable signs" by it. No less an authority upon telegraphic science than Mr. Latimer Clark, has stated, upon evidence which cannot be questioned, that my transmitting slip for the alphabet has only 82 perforations, and measures only 10¼ inches, against 164 and 14 respectively on the Post-office system. That my alphabet receiving-slip measures less than 5 inches, against 15 inches by the system in use at the Post-office. That, instead of the signals failing, as Professor Jenkin stated, Mr. Latimer Clark finds my instrument capable of recording 1,600 perfect signals in a minute, and that this has been actually accomplished by an instrument which has been subjected to harsh experiments for several years, and was not made by a first-rate maker. Mr. Latimer Clark also affirms that my system would not only surpass the system in use at the Post-office, both in speed and accuracy, but that it would save nearly 75 per cent. in the cost of paper.

The fact of the instrument which I submitted for trial not having been made by a first-rate maker, introduces another division of my costly experience of the Telegraph Department. Owing to the influence of the engineers of the Telegraph Department of the Post-office upon the instrument-maker I first employed, I was compelled to seek for other assistance, and applied to several makers without success, and as this difficulty seemed to become increasingly serious, I mentioned the fact to the Secretary of the Post-office. In replying to my letter, he said, "You do not appear to be conscious that you are imputing dishonourable conduct to honourable and upright public servants," and after contradicting me five times, saying twice, "It is not true," he informed me that he had written to three of the instrument-makers whose names I had mentioned, and had requested each of them to explain; and yet, without waiting for their replies, he added, "I must request you at once to withdraw the imputation, which should never have been made." As it was impossible for me to withdraw a single word that I had communicated to him, I simply acknowledged the receipt of his letter, and awaited the result of the inquiries which he informed me he had made. In a few days I received a letter stating the result of those inquiries, and requesting me once more to withdraw the imputations, to which letter I replied as follows:—

"I do not impute dishonourable conduct to any man when I say that I have reason to fear your letters to the three instrument-makers I mentioned have rather tended to increase my difficulty than to lessen it. I have called on two of the gentlemen in question, and have written to the third. In one case I have been told that the extract with which you favour me is not to be found in the reply given to the letter which you stated you had addressed to my informant. In the second case, I am told that the reply given to you was intended to strengthen rather than to weaken my remarks, and that more than one personal experience was narrated by your correspondent in support of my observations. In the third case, my informant writes to admit that when I called on him he said, 'It is not likely that one would like to offend anyone by whom one was employed.'"

And it is worth relating that, after all this, I was introduced by an electrician of the highest standing to a well-known telegraph-instrument maker, who actually declined to carry out any ideas because he also feared to offend the Engineer-in-Chief; but he recommended me to another maker in the strictest confidence, who made the instrument which has sufficed to furnish the interesting results thus far attained.

If any demonstration were needed of the hopelessness of expecting fair play for an outsider from the telegraph authorities, their conduct in reference to the recent Loan Exhibition of Scientific Apparatus at South Kensington would supply it. At that exhibition the Postmaster-General exhibited the instruments which I entrusted to the Post-office for the purpose of the proposed trial. But, although the instruments were exhibited, they were at first omitted from the catalogue and labelled incorrectly. When a second edition of the catalogue was being prepared, I applied to the director of the exhibition for permission to write or revise a description of them. Instead, however, of obtaining such permission, the director, Mr. Cunliffe Owen, replied, "The General Post-office can alone be recognised as the exhibitor of the instruments, and the only description that can be accepted for the catalogue, is that which has been furnished by it." I then applied to the Postmaster-General, who answered by his secretary, that the "labelling and description of the various instruments exhibited had been carried out under the supervision of the authorities of the exhibition, and that his lordship must refer me to them as regards the labelling and description." I again applied to the director of the exhibition, who answered that the description of the instruments had been furnished to him by the Postmaster-General.

The next instrument to mine in the second edition of the catalogue, numbered 1.564 E, was described as printing the signs transversely. Now, it cannot be doubted that this erroneous statement was made by the authority of the Post-office, and might be altered by the same authority. It was manifestly so described to produce the impression that the Post-office had another instrument which would do what mine did. But the authorities of the Post-office would not state this distinctly, because they would then be liable to be asked why, if they had got such an instrument already, they had spent money in trying mine. But, although this statement could not be made, it might be insinuated, and when I challenged the covertly hostile paragraph, I was told that the responsibility for it rested with the officers of the exhibition, who, however, met this assertion of the Post-office with a distinct and positive denial.

The limit necessarily assigned to this article prevents my entering further into this painful question, but I shall be happy to forward a copy of my case as presented by the Secretary of State to Her Majesty to any gentleman who may wish to possess it. I will only add in conclusion that upon all points the Post-office has broken faith with me. It promised that there should be a full and fair trial of my system. It invited me to make costly preparation for such trial. It induced me to engage and to pay two eminent scientific gentlemen to represent me at the trial. It arranged and signed terms of reference. It promised to adopt my system if the trial proved satisfactory. It obtained possession of my instruments under a written promise to proceed with the trial. It broke all those promises. It has given no reason for doing so. It has never appointed a meeting of the referees. It has not replied to my application to be reimbursed for the consequent loss of my time and my money. It has neglected to deal with my petition for redress, although such petition has been referred to it by the Crown. RICHARD HERRING.

THE POST-OFFICE AND RECENT ADVANCES IN TELEGRAPHY.

In the *Journal* of August 23rd was published a paper read by Mr. W. H. Preece, before Section G of the British Association, at the meeting lately held at Dublin, entitled "Recent Advances in Telegraphy."

The object of this paper, as stated by the author, is to prove that since the transfer of the telegraphs to the State, this monopoly, instead, as has been publicly stated by very high authorities, of having checked invention in telegraphy and driven it to America, has, on the contrary, stimulated invention in this branch of science. Mr. Preece adds that greater improvements have been made in telegraphy in England during the past eight years than in any previous period of similar duration, and that improvement in telegraphy was never more active in England than it has been since the Government has managed the business.

One naturally, as an Englishmen, on reading such statements made by a gentleman so well known and highly qualified as Mr. Preece should be to give an opinion, cannot but feel flattered, more especially as from his recent visit to America in an official capacity, Mr. Preece has had every advantage in studying the various systems, and the extension to which telegraphy is at the present day carried in America.

On perusal, however, of Mr. Preece's paper, this feeling of satisfaction gives place to one of disappointment. Instead of having made good his case, his paper has, on the contrary, but too clearly shown us our own deficiencies, and proved that we have not much to boast of in the way of English original ideas, as far as the postal telegraph service is concerned.

Let us take the principal improvements in receiving apparatus mentioned in the paper, viz.:—Varley's and Spagnoletti's induced needles, to remedy the disturbances due to atmospheric electricity; Siemens' direct ink writer, to remedy the irksomeness to the eye of the embossed paper of Morse; Sir W. Thomson's syphon recorder and Varley's condenser, both of these being designed for expediting the rate of working through long submarine cables; Bain's chemical recorder (reproduced after many years interment), for expediting the speed of automatic working through long circuits; Neale's acoustic coil, for assimilating the single-needle and bell systems; Bell's telephone, which, however, is employed only on a limited scale in England.

Now, it is a curious fact that of these inventions, S. A. Varley's patent was taken out in 1866, Spagnoletti's in 1869; Varley's condenser was patented in 1862; whilst Siemens' instruments, in which ink was substituted for the old plan of embossing, were certainly in use as early as 1859. These dates, as will be seen, are all of them prior to the transfer of telegraphs to the State, which took place at the end of January, 1870. Sir W. Thomson's syphon recorder, patented in 1867—again prior to the transfer—is an instrument for which there is no use in the service. There is not even a cable of sufficient length to be called a cable in the sense of cable-working worked by the Post-office, hence, of course, there is no necessity for employing such an instrument, although I believe one is owned by them, put away in some out-of-the-way room as an ornament. The monopoly, then, can hardly be said to have fostered this invention, or in any way led up to it.

Varley's condensers, as already said, were patented in 1862: they are

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now largely used in multiplex telegraphy. But their application for this special purpose came from America, as will be seen further on. Also to Mr. Edison, of America, we are indebted for the resuscitation of Bain's chemical recorder, as the instrument had been entirely given up until he came to this country and demonstrated to the Post-office electricians the possibility of employing it as a fast speed instrument. Of the Neale's acoustic coils the system has not been thought sufficiently advantageous by the post-office electricians to justify its adoption; it is said to have been tried, but apparently did not meet with the approval of the Post-office electricians, as it is not used in the service.

In speaking of the Bell telephone, Mr. Preece himself states further on that it is too sensitive an instrument for practical use in existing lines, and notwithstanding some time has elapsed, it does not appear that any steps have been taken to utilise it.

With respect to sources of electricity, two batteries are named, that of Leclanché and Fuller, but Leclanché's patent was taken out in 1867, and, besides, he is a Frenchman, so unfortunately, the English can hardly lay claim to it, or the Post-office flatter themselves with having had anything to do with the matter. Whereas Fuller's modification of Poggendorf's form of the old bichromate battery is said not to be a sufficient alteration to render his patent valid.

In sources dependent upon motion in a magnetic field we are apparently still more unfortunate; of the three inventors named, viz., Wild, Siemens, and Gramme, Wild is the only one that is an Englishman, his patent dating from 1863, here again prior to the transfer, whilst Siemens is a German, and Gramme a Frenchman. Besides, as Mr. Preece states, no machines depending upon this principle have yet shown themselves equal in efficiency to batteries for telegraphic purposes.

In sources of electricity dependent on the conversion of heat into electricity, M. Clamond's thermo-electric pile is a purely French invention, it having been brought to this country after it had been perfected in France. We can, therefore, hardly in fairness lay claim to it, as most certainly it was the French that proved that the thermo-pile must in the future be looked upon as something more than the philosophical toy it had hitherto been. Mr. Leonard Wray has, it is true, since the winding up of the Clamond Pile Company in England, with which he was connected, somewhat modified and improved the original form of M. Clamond, but these improvements, Mr. Preece states, have been without any decided results.

In the manufacture of iron wire Mr. Preece mentions that "England stands pre-eminent; Messrs. Johnson, of Manchester, have led the way with their continuous rolling method," and further on he states that "the Americans have adopted Johnson's method of manufacturing iron wire." Here, again, there seems a slight discrepancy, as the continuous rolling method is an American invention, and it is we who have copied the Americans: whilst it must not be lost sight of that at the present time foreign countries are largely supplying the English cable manufacturers with iron wire not only equal in quality, but even in some cases superior, and certainly at a lower price.

The Wheatstone automatic system was a practical success before the transfer of the telegraphs. It can therefore hardly be claimed as an offspring of the Post-office electricians' ingenuity. Why, its very existence at the time the lines were taken over, and the great increase of work consequent on the shilling tariff, was one of the chief things that enabled the Government to so successfully grapple with the difficulty.

It is true that the Wheatstone A B C instrument is a very clever and ingenious piece of mechanism, but as to its being entirely remodelled such a statement appears rather more imaginary than real. It has been altered to a certain extent, but hardly to that degree that Mr. Preece's paper would lead one to suppose; but it is not the only instrument of the class. In France we should be told it did not compare with Bréguet's A B C instrument. In Germany we should hear that Siemens' A B C was better, whilst in America there is more than one instrument of a similar class that prints the messages on a slip of paper in Roman type quite as effectual in working as the Wheatstone A B C, which does not print. The Post-office are so far right in employing the instrument for the use of which they have paid so highly. It is, probably, quite equal to any of the others mentioned, and they wisely do not adopt a multiplicity of types of instruments. It is but right to mention this, as from what has been said, one would have inferred that the Wheatstone A B C instrument stood alone of that class.

Further on, a paragraph states "That the distinguishing feature that has characterised the improvements made by the Post-office officials has been in the direction of fast speed telegraphy; and it is not too much to say that they have more than quadruplexed the working 'speed of wires.'" Here we must not overlook the fact that it was Mr. Edison, an American, who came to this country, and by his method of using an adjustable electro-magnet as a shunt with the Bain chemical instrument, successfully demonstrated to the Post-office the possibility of advantageously employing the Bain instrument for high-speed working, the difficulty having been hitherto the running together of the signals from induction when high speed was attained. Also, at a still more recent date, we are indebted to America for the duplex system being brought to its present state of perfection. This system was introduced to England by Mr. J. B. Stearns, an American, to whom the Post-office paid a considerable sum for the right of using his invention. Mr. Stearns it was who devised the arrangement of Varley's condensers and resistance coils which have enabled the duplex system to be so successfully used, and, in Mr. Preece's own words, "made duplex telegraphy a practical success."

Quadruplex telegraphy, Mr. Preece shows, is now being introduced by the Post-office, after having been perfected in America, where, on the Western Union telegraph lines, it is now applied to sixty circuits. It certainly has not yet reached this state of extension in England.

With regard to what Mr. Preece terms in his paper "harmonic telegraphy," Mr. Cromwell Varley does not appear to have been much encouraged by the Post-office in his plan of increasing the capacity of the lines; yet in America (so Mr. Preece states) we find that "it remained for Mr. Elisha Gray, of Chicago, to work the system out practically. This system is now under trial in America, and it is exhibited at the Paris Exhibition, where Mr. Gray is also showing an octoplex system, or a mode of sending eight messages on the same wire at the same time, which is said to have been experimentally tried with success between New York and Philadelphia." Let us trust, therefore, that should the success of this system prove as beneficial as the above statement would lead us to suppose, our Post-office electricians will have the good sense to make use of the invention, whilst, at the same time, they give due credit to the inventor.

Really, when we look at all the points brought forward in the paper to prove the benefit that the monopoly of the telegraph by the State has been, in stimulating invention in England, it does appear that the so-called proofs would be apt to make one believe quite the contrary.

Not one single case has been quoted in which, since the transfer of the telegraphs to the State, one single English invention has been made and introduced into the Postal Telegraph Service. On the other hand, it has been shown that the service has not failed to make use of some valuable American inventions, and these it is, in truth, which have in a great measure assisted the Postal Telegraph Service to its present high state of perfection. At the same time, we must not lose sight of the fact that the Post-office electricians have improved many of the instruments that were in existence when the lines were transferred, more especially the Wheatstone automatic instruments as well as the lines themselves, and brought everything into a much more efficient state, modifying existing instruments to suit the requirements of so vast a service as that of the Postal Telegraphs. After all, this is perhaps the least we could expect of them, as they alone would be in a position to judge of the weakness and requirements of the service, so far as electrical matters are concerned.

It has been remarked in the paper alluded to, that in England the Morse recorder is now being slowly replaced by the simpler sounder, the principal instrument for many years past in use in America. A curious statement is said to have been made by a well-known American electrician, a short time since. He said, "You English have adopted the sounder from us, but have pitched upon one of its worst forms as your pattern." This statement, whether true or not, seems to be in some measure borne out by the fact, that since Mr. Preece's return from America an entirely new pattern (American) sounder is being constructed, which one learns is to take the place of the old form, and is to be the English type for the future.

Take a number of the telegraph instruments of late construction used in the service, more especially such as are used for fast-speed sending; they are as near a copy of American designs as possible. Let them only have American-shaped terminals, the brass work nickel plated instead of lacquered, and fix them upon a more ornamental base, and one would hardly recognise them from the originals.

In the list of patents for improvements in telegraphy we find published in Mr. Preece's paper, it is shown that whereas for the eight years prior to the transfer the yearly average was 48¼ patents, that for the last eight amounted to 52¼. This increase of some seven per cent. hardly strikes one as being very great, when we take into consideration the large increase in the telegraph stated to have taken place outside that of the Government, which is said to be as great now as the whole telegraph system of the country was before the transfer. Besides, now-a-days, a foreigner no sooner takes out a patent in his own country than he also patents his invention in England, especially such as touch upon electrical matters. Then, again, look at the number of domestic applications for which electricity is now coming into use, which, eight years ago, were not so much as thought of.

Next, take the statement made, that—"It is, perhaps, in improvements in conductors that England has shone most; she has supplied the world with cables." For such improvements, surely Mr. Preece would not wish us to infer that they have been caused by the Government monopoly of the telegraphs. On the contrary, one would far more readily suppose that it was the competition that exists between the various cable companies that has brought about these improvements.

Vast improvements have, without doubt, of late years been made in England in submarine telegraphy, both in the manufacture of cables and that of instruments whether for testing or signalling purposes, but one would be inclined to look to the existing competition in this branch, rather than the Postal telegraph service as having effected it.

The following paragraph speaks for itself:—"In 1863, the Western Union Telegraph Company, feeling that their telegraph system was not up to the requirements of the age, secured the valuable services of Mr. Cromwell Varley, who educated them up to the European standard of electrical knowledge, and they have certainly bettered the instruction." From this, one would infer that, about a year or so before the transfer, America was behind England in telegraph matters, yet from that date to the present time America appears certainly to have profited by Mr. Varley's tuition. Some of the most valuable improvements of late years, viz., those of multiplex telegraphy, have come to us from America. These are inventions essentially brought about by competition, and not monopoly. Now, in the same space of time, Mr. Preece fails to show us what we can boast of, with the exception of having copied America, although at the start it must be remembered we were already ahead of them in electrical knowledge.

Towards the close of Mr. Preece's paper appears a paragraph, which, if true, must be highly flattering to the English nation; it states:—"The fact remains that telegraphy, whether for commercial or railway purposes, is more highly developed in England than in any other country, not excepting America, and this development is due as much to the action of the State in purchasing and managing the commercial system of the country, as to the competition that remains between nation and nation, and between company and company."

It is easy to make such a statement, but quite another thing to prove it. In England we have a really well organised telegraph system as far as commercial messages are concerned. We have not failed to make use, it is true, of foreign experience as well as our own, and from this, in a commercial point of view, we must reap a benefit. We have a system of private wires rented at fair prices, and maintained in efficient working order throughout the country. This, then, is the high state of development that the monopoly of the telegraphs has brought about. Such a system as fire-alarm telegraphs has not yet been instituted in England. In speaking of fire-alarm telegraphs it must be understood that what is alluded to is not a simple telegraph wire and instrument connecting certain fire-engine stations, as at present exists, but a thoroughly organised system, whereby, in case of a fire occurring, by means of instruments placed at certain intervals throughout a town, a policeman or other person may, by pressing a button or some such arrangement, start the automatic apparatus, which will then telegraph to the nearest station, thus giving the alarm, and indicating the spot at which the engines are required; this information, received at the central station, in its turn can then be simultaneously, if required, communicated to any number of stations. Both in America and on the Continent,

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fire-alarm telegraphs have been successfully at work for some time, more especially in the former instance, where the system has been brought to a high state of perfection. Then, again, have we anything like the American plan of distributing news now at work in some of their large cities, where, by the payment of a small annual rental, an automatic instrument is put up in your place of business, connected to a central office, through which, from time to time, the current news of the day is distributed. The message is printed in Roman characters on a slip of paper in the instrument, without need of any control on your part. Thus, by simply taking up the slip, you may see printed before you the latest news. The system is worked by some of the neatest instruments in a mechanical point of view yet invented for telegraph purposes. Nor have we the American Stock Exchange telegraph, where quotations of the stocks are circulated to subscribers entirely automatically. This latter we certainly have to a limited extent in connection with the London Stock Exchange. It is, however, worked by the Exchange Telegraph Company and not by the Post-office. The extent of the system is limited, as the Post-office authorities will only permit the company to work within a very few hundred yards radius from the Exchange. This and other difficulties put in their way by the Post-office, has in a great measure prevented its extension. The instruments used by the company are purely American inventions, England not yet having invented an instrument capable of meeting such requirements.

With regard to our cable companies and electric systems as applied to railway working, we surpass all other nations; but here the question of competition is in full force, and these advances must be looked upon as having been brought about by the existing competition rather than from any monopoly owned by the State.

It may be asked in what way the Post-office can be blamed for not having instituted some system of fire-alarm telegraphs, as surely this was a matter for the Board of Works and town councils to take up. In answer to this, it must be remembered that these public bodies look to the Post-office for guidance in such matters, whilst the Post-office do not seem inclined to recommend a system. Then, again, private enterprise can do little in the way of private telegraphs in instituting a plan of distributing news or any similar system, as may be seen from the difficulties experienced by the Exchange Telegraph Company in even trying to extend their field of operations. And, further, this jealousness, if we may so call it, seems to be borne out by the attempts lately made by them of quietly getting a Bill through Parliament, which Bill would have enabled them to retain the entire monopoly and control of all private wires throughout the kingdom. Thus no private individuals would have been in future permitted even to erect a line of telegraph between, say, his works and place of business, or even own such a line. This would certainly have put a stop even to the chance of private enterprise.

The object of this communication is not in any way to throw blame on the postal authorities for their apathy in not establishing some such telegraphic systems as have been mentioned, but rather to show in their true light how the various points mentioned in the paper alluded to really stand. Private enterprise might still do much, and we ourselves are quite as much to blame in the matter. As an instance of this, we need not seek further than that of the telephone. Mr. Preece informs us it has not yet been employed in England other than on a very limited scale; whilst we learn from America that the Americans already have some thousands at work with a system of wires erected expressly for them in connexion with a central office, by which means such as have utilised the system are enabled to converse with each other as required. The following paragraph from the *Telegraph Journal* of August 15th will give some idea of the extent to which they are used in America:—"Under the American patents, some 14,000 telephones have during the past year been installed in the United States, and are being rented at an average rental of 10*l.* per annum; and fresh orders are being received at the rate of 1,000 sets per month." Unfortunately, however, in England we are slow to take up new inventions, resting contented with such flattering remarks (on a subject unfamiliar to many of us) upon the high advanced state of the English postal telegraph service as may be made to us from time to time by scientific lecturers and experts like Mr. Preece.

Mention has been made in Mr. Preece's paper of the vast extension to which the present telegraph system has been developed; and no doubt we have arrived at a higher state of development than had the telegraphs remained in the hands of the old companies. The Government, on taking over the telegraphs, were in a position to effect far more, by way of extension, than any private enterprise could possibly do. They already possessed a thoroughly well-organised postal service, in connection with which the telegraphs were to be worked. In many towns which the telegraph had not then reached, postal communication was in efficient working order, so that where, with the old companies, it would not have paid, in a commercial sense, to establish an office and clerks, with the Post-office the office already existed, and the then Post-office *employés* soon found it a *sine quâ non* that they must be acquainted with the manipulation of the telegraph instruments.

Yet, while acknowledging the great extension of the telegraphs made by the Government, it should be mentioned that this extension would not have now reached its present size, had it not been for the great activity of Mr. Scudamore, who stole a march on the Chancellor of the Exchequer, and secured for the public that rapid and vast extension, which, if all official forms and red tape had been strictly adhered to, we might still have been seeking in the future.

In conclusion, we ought all to thank Mr. Preece for his very able paper, which, if it has not substantiated the proofs of the benefit to be derived from a Government monopoly of the telegraphs in stimulating invention, has, on the other hand, pretty clearly demonstrated to us our backwardness on these points. Let us hope that, for the future, this lesson may not be thrown away.

A TELEGRAPH ENGINEER.

ERRATUM.—In Mr. Adam's article on "Dia-Electric," the last paragraph but one of the article under the above title should read: "My investigations appear not only to have elicited the fact of *dia-electricism, &c.*," instead of "the fact of *dia-magnetism, &c.*"

RECENT PATENTS.

4468. APPARATUS FOR THE ELECTRIC TRANSMISSION OF TELEPHONIC COMMUNICATIONS, *L. M. de Bejar y O'Lawlor.—Dated 27th November*, 1877. 6*d.*

This relates to improvements on patent No. 2327, dated 4th July, 1873, in which any number of telegraph instruments are in communication with a central station by the same set of line wires, and one apparatus can never cut off the transmission of signals from another that may be at that moment operating with the station until the latter instrument has ceased operating. The improvements consist in the application and combination with this apparatus of transmitting and receiving instruments of the kind known as "telephones."

4885. TRANSMITTING, RECEIVING, AND PRINTING TELEGRAPHIC MESSAGES, *F. J. Bolton.—Dated 24th December*, 1877. 6*d.*

Perforations are caused to be made on the slip in lieu of coloured marks, or such marks are converted into perforations by chemical, physical, or mechanical means; or a conducting slip is employed on which insulating marks are produced by the agency of the electric current, or *vice versâ*. The marks or punctures are arranged in groups, which groups, as well as the individual marks or punctures, shall be approximately at regular and determined distances from each other; this is effected by means of any convenient form of regulator attached to either the sending or receiving instruments, or to both, or by means of currents of electricity which are made to start, stop, or regulate the receiving instrument.

4903. MAGNETO-ELECTRO MACHINES, *W. R. Lake.—Dated 27th December*, 1877.—*(A communication.)* 1*s.* 2*d.*

In machines of which the revolving armatures are annular the coil is arranged thereon in radially divided systems, so connected by loops and bridge wires that the larger portion of the current generated by the sweep of any one system through the magnetic field is conducted directly to the commutator, without passing through the other systems of coils. The armature and its ribs are hollow and have openings, so that currents of air pass through and prevent over-heating. The commutator consists of a series of flat metallic sectors insulated from each other and radially mounted upon the surface of a rotating disc. There are as many sectors as there are loops, and they are each connected by a wire to one of the loops.

275. SEMI-AUTOMATIC APPARATUS FOR TRANSMITTING TELEGRAPH MESSAGES WITH THE MORSE SYSTEM, *T. J. Smith.—Dated 21st January*, 1878.—*(A communication.)* 10*d.*

Two contiguous finger keys, one for points or dots and the other for dashes, strokes, or lines, are joined by two vertical rods to a double branched interruption lever, the lowering of which must determine the contact which closes the circuit. The ends of the two branches upon which the rods of the keys act are furnished with distinct appendages, so combined that the oscillation of the interruption lever is effected differently, according as it is desired to produce a short or long contact. By this arrangement the operator has not to trouble himself about the duration of the contact to be furnished; it is sufficient for him to lower one or other of the keys according as he wishes to send lines or points.

307. TELEPHONE, *D. Pidgeon.—Dated 23rd January*, 1878.—*(Not proceeded with.)* 2*d.*

An improved "call" is obtained by making the telephone with a horse-shoe magnet and placing between the poles a small revolving armature. A current interrupter cuts one or more of the currents generated at each revolution of the armature. To operate the call the armature is made to revolve rapidly by means of a hand wheel and pinion, and the currents thus sent are strong enough to cause sufficiently powerful vibrations of the disc to be heard throughout a large room.

312. SUBMARINE TELEGRAPH CABLES, *H. Clifford.—Dated 23rd January*, 1878. 4*d.*

A tape or riband is laid round the gutta-percha or insulated cores in a spiral form. The tape is prepared as follows:—Felt or other fibrous material is coated with a mixture of resin and resin oil or marine glue, or pitch and resin oil, and whilst warm the material is pressed upon one or both sides of thin wire gauze, sheet brass, or other metal, and pressed between rollers.

TELEGRAPH SHARE LIST.

COMPANIES.	CLOSING PRICES SEPT. 11.	BUSINESS DONE WEEK ENDING SEPT. 11. Highest.	Lowest.
Anglo-American	60¾, 61¼	61⅛	60¾
Do. Preferred	90½, ¾	91	90½
Do. Deferred	34, ½	34	33½
Brazilian	6¼, ¾	6⅝	6½
Cuba	9½, 10	—	—
Do. Ten per Cent. Preference	15½, 16½	16	—
Direct Spanish	1½, 2	—	—
Do. Ten per Cent. Preference	9¾, 10¼	10⅛	10
Direct United States	13, ½	13¼	—
Eastern	7⅜, ⅝	7½	7 5-16
Do. Six per Cent. Debenture	106, 108	—	—
Do. Five per Cent. do.	99, 101	101	100½
Do. Six per Cent. Preference	11 9-16, 11-16	11⅝	11½
Eastern Extension	7 5-16, 7-16	7 7-16	7 5-16
Do. Six per Cent. Debenture	106, 109	107½	107¼
German Union	7¾, 8¼	—	—
Globe Telegraph and Trust	5¼, ⅜	5⅜	5¼
Do. Six per Cent. Preference	10 15-16, 11 1-16	11⅛	10⅞
Great Northern	8, ¼	8⅛	8⅛
Indo-European	20½, 21½	—	—
Mediterranean Extension	3, ½	—	—
Do. Eight per Cent. Preference	9½, 10	—	—
Reuter's	10, 11	—	—
Submarine	217, 222	—	—
West India and Panama	2⅛, ⅜	2¼	2 3-16
Do. Six per Cent. Preference	8⅝, ⅞	8 13-16	8⅝
Western and Brazilian	4, ½	4¼	4 1-16
West. Union 7 p. Cent. 1st Mortgage	114, 118	—	—
Do. Six per Cent. Sterling	99, 101	—	—

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NOTES.

Cyprus and Alexandria.—An expedition has started to connect Cyprus with Alexandria, and thus to England, by means of a submarine cable.

Nickel.—This substance loses all its magnetic properties when alloyed with about ten times its weight of zinc.

Wheatstone's Definition of Electromotive Force.—The cause which originates *current* in a closed, and *tension* in an unclosed circuit.

In Its Youth.—At the time (1846) of the foundation of the Electric Telegraph Company, formed to work Cooke and Wheatstone's patent, there were 964 miles of line in actual operation.

United States v. England.—There are 79,000 miles of telegraph wire in the United States and 6,850 offices, or one mile of line to every thirty-six square miles of area. England has 75,000 miles of line and 5,600 offices, or one mile of line to every mile and a half of area.

Trees and Telegraphs.—The *Lumberman's Gazette*, in an article on "the Protection and Perpetuation of Forests," referring more especially to America, has the following sentance:—" We have 75,000 miles of wire, which requires in its putting up 800,000 trees; while the annual repairs must take 300,000 more.

Direct Spanish Telegraph.—The net profits for the half year ended 30th June were 3,411*l.*, this result being due, it is stated, to the continued depression in trade. The preference dividend requires 2,921*l.*, leaving 490*l.*, or 20*l.* less than the amount required to discharge the arrears of 1*s.* 9*d.* per share outstanding on the preferences. The directors therefore recommend that these arrears be paid off, the deficiency being taken from reserve.

A New Battery.—A new battery is described by Ponci, an Italian electrician, which is said to be novel and of great simplicity. It consists of a glass jar and a porous vessel, the latter filled with a solution of ferrous chloride, and having an iron plate as a pole. The outer solution is of ferric chloride, with a carbon as a pole. Both solutions should be made up to a strength of thirty-five degrees Baumé. The electro-motive force is said to be nine-tenths of a Daniell cell.

Duplex Transmission.—Who first discovered that currents of electricity could pass on the same wire? In a letter of Professor Morse, dated January 17, 1843, he states that he and Professor Fisher discovered that several currents of electricity will pass upon the same wire without interference, either in the same direction, or in opposite directions, and that the discovery was reduced to practice. The arrangement of the circuits was somewhat like ∞, each segment including a cell and an electro-magnet. When both circuits were completed the current was found to be common to the two circuits.

Yellow Fever at New Orleans.—Whilst we in England are sorrowing over a series of accidents which have caused an immense loss of life, the Americans are deploring the wholesale depopulation of many southern towns, owing to the ravages of yellow fever. The *Operator* gives a list of sixteen telegraph *employés* at New Orleans attacked by the fever—one of whom, Hugh Irvine, succumbed on August 24th. The Western Union Telegraph, in whose employ are many of these men, has given orders that nurses shall be provided where necessary, and the telegraph *employés* throughout the country are organising for the relief of their stricken brethren.

Cable to Cyprus.—This week the ss. *Great Northern* left Gravesend with about 500 miles of submarine cable on board, for the purpose of connecting Cyprus, by means of a cable, with Beyrout and with the Eastern Telegraph Company's cable at Alexandria. When these connections are made, the island will be in direct cable communuication with England. Previous to the departure of the ship, it was visited by the Right Hon. Robert Lowe, M.P., in company with Mr. J. Pender, M.P., the chairman of the Eastern Telegraph Company; also by Sir J. Anderson, managing director. The expedition is in charge of the engineering staff of the Telegraph Construction and Maintenance Company, which company has constructed the cable.

The Mariner's Compass.—Many people look upon the compass as an introduction of the fifteenth century, but it seems to have been well known in a primitive form in the twelfth and thirteenth centuries. In one of the popular songs written in the time of King John, it is said that the sailors who go on long voyages to Friesland or to the East know their way by observing the *tramontaine*, or polar star; but, when the sky is covered with clouds, and they could no longer see the stars of heaven, they had a contrivance which was this: they took a needle of iron and put it through a piece of cork, so that one end remained out, which they rubbed with the loadstone, and then they placed it in a vessel full of water, and, whichever way the end of the needle pointed, there, without any doubt, was the polar star. This formed a primitive but fairly perfect mariner's compass.

Artificial Globe Lightning.—A curious electrical phenomenon has been lately observed by M. Planté. One of the mica condensers of his rheostatic machine being placed on an insulated metallic plate connected with one of the poles of the secondary battery, and the upper armature being touched by the other pole, an electric spark appears at one of the points of the condenser, where the mica is too thin or presents a slight fissure. This spark moves along in the form of a small, very brilliant, luminous globule, accompanied by a a peculiar crackling, and traces slowly on the tin sheet of the condenser a deep, sinuous, and irregular furrow. The effect is regarded as throwing new light on the phenomenon of globular lightning. The elements of a condenser are, probably, then formed, in which a moist column of air, strongly electrified, plays the part of the superior armature, the ground that of the lower armature, and the air layer between that of the insulating plate.

A New Magneto-Electric Machine.—We were informed, when in Paris, that M. de Meriten had invented a new machine which surpassed in effectiveness all that had been done previously in the direction of magneto-electric machines. M. du Moncel stated that it went far towards the solution of the more extended use of the electric light, and this gentleman has fully described the machine in a recent number of *l'Electricité*. We shall reproduce the description, with the illustrations, in our Paris notes; meanwhile, the machine is said to be capable of lighting three or four Jablochkoff lamps per horse-power. This being the case, the machine is three or four times more effective than that of Gramme, which hitherto has distanced almost all competitors. With some recent improvements in electric-lamps, which we hear are better than the Jablochkoff candles, combined with this new machine, we ought to have no great difficulty in introducing "more light."

The Thread Telephone.—N. R. Huntley, engineer at the Connecticut River Railroad Shops, Springfield, Mass.,

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who succeeded in operating a twine telephone across the river, a distance of 1,426 feet, has been further experimenting, and is now able to talk freely and plainly across the river, a distance of 2,450 feet, or within 190 feet of half a mile. For boxes, or mouth-pieces, he uses the same tin ones as with his previous experiment, except that for the silk disk he substitutes thin button iron. To make the experiment more complete and seemingly more difficult, he has run his line in a zig-zag way, making numerous angles, but finds that it is no less effective than if perfectly straight. For hangers he uses heavy wire pins, on the ends of which he fastens small non-conductors of glass, the line being fastened to these by a loop of twine about half an inch long. Without these non-conductors the sound passed off at each support. Mr. Huntley has not the least doubt of his ability to use these lines at a distance of a mile, and, perhaps, further, and is also confident that for ordinary use, such as carrying on conversation between neighbours and friends, they will be brought into general use.—*Boston Advertiser.*

The Telegraph in Japan.—With the opening of a new Central telegraph office at Tôkio, Japan has undertaken the task of conducting hereafter the foreign telegraph business of that country. It is less than eight years since the first telegraph in Japan was erected, and there are now nearly six thousand miles of wire in operation. And, what is more remarkable, probably, is that the whole of the Morse instruments in the new head office, as well as "test-box," and a "cronofer," or time transmitter, by which the correct time is transmitted daily to the one hundred and twenty-five offices in Japan, are of native make. In fact, it is stated that wire is the only part of the telegraph system which is now imported, and it is expected that even the wire may soon be manufactured. When the new office at Tôkio was thrown open to public inspection, before being used for business, the building was inconveniently crowded by multitudes of the lower orders of Japanese, who seemed "unwearied in displaying their open-mouthed enjoyment and surprise at the novel spectacle presented to them," and to look with delighted awe on the small and simple-looking instruments which they knew would in some mysterious way convey a message instantaneously to places far distant. The introduction and developement of the telegraph in Japan is due to Edward Gilbert, the English Chief Superintendent.

Further Telephonic Experiments.—Mr. F. G. Lloyd gives in *Nature* the following account of a very curious experiment: — "Two ordinary electro-magnets — unscrewed from a couple of large electric bells—were fastened, by means of two little wooden saddles and a screw each, to a small piece of deal board about 4½in. square and ⅝in. thick, in such a way that the poles were all but touching. Their wires were then joined so that poles of opposite denominations faced each other, *i.e.*, north opposite south and *vice versâ*. This, placed on an empty cigar-box and four Leclanché cells in circuit, gave out the tune of a musical box clearly and loudly in the room. When both poles were made to touch, the sound ceased; but, with a thin piece of paper or stout tin-foil between them, without any intervening air space, the sound was heard. On gradually separating the magnets, the sounds grew fainter and fainter, till they became inaudible. By putting the base-board close to the ear, whistling and singing to the microphone were very clearly and loudly heard, also the voice of the person speaking could be recognised; but words were hardly sufficiently defined to distinguish all that was said, though now and then parts were intelligible. One of the electro-magnets was afterwards replaced by a small permanent steel horse-shoe magnet fastened to the board in a similar manner; the result was the same, but slightly louder, probably from there being less resistance. By varying the strength of battery, size, or mode of mounting magnets, or adjustment of the microphone, I have no doubt that perfect definition can be obtained. The loudness and volume of the sound are ample; but, before making further experiments, for which I have at present little time, I hasten to communicate the fact that the electro-magnet, without any diaphragm whatever, can be made a reproducer of sounds transmitted by a Hughes' microphone, and thus a complete and practical telephone system produced without the possibility of infringing anybody's patent."

The Micro-Telephone.—"G. M. Hopkins," in an illustrated article in *The Scientific American* describes a new instrument of his invention. We believe that our readers can easily understand his work and reproduce the instrument without the illustrations. He says:—"The Edison carbon telephone and the instrument known as Hughes's microphone—which, according to general belief, are identical as to principle—depend, according to the inventor's theory, upon the changing conductivity of carbon under a varying pressure. It has been generally admitted that no instrument that would make and break the electric current could transmit articulate sounds. Nor has such an instrument, to my knowledge, been produced prior to the one shown in the accompanying engravings. My instrument, so far as I know, differs materially from the multitude of other forms of telephone or microphone, which are all based upon the principle discovered by Edison. The instrument which is the subject of this article consists essentially of two springs secured to a small base piece, and each supporting at their upper end a piece of ordinary battery carbon. These two pieces of carbon are placed in light contact, and the two springs are put in an electrical circuit, in which there is also a receiving telephone of the Bell form. The two carbon supporting springs are fastened to a single base by the binding posts which receive the battery wires. An adjusting screw passes through one of the springs at or near its centre, and bears against a rubber-button projecting from the other spring. This simple device, when placed on a table, indicates in the receiving telephone the slightest touch of the finger on the table or on the instrument. Blowing on it makes in the receiving instrument a deafening roar; drawing a hair or a bit of cotton across the carbon is distinctly audible in the receiving instrument. When the device is placed on a small sounding-board every sound in the room is received and transmitted. An ant running across the sounding-board can be plainly heard. And a touch upon the instrument or the table which supports it, which without the micro-telephone would be entirely inaudible, can be distinctly heard in the receiving telephone by aid of the instrument, even though miles intervene. When it is placed on a violin, blowing lightly upon the strings produces Æolian harp accompaniment. When mounted on a violin or sounding-board it will transmit articulate speech uttered in any portion of a room of ordinary size; it will receive and transmit the music of a piano, and even the turning of the music may be heard. Whistling, flute music, and other sounds are transmitted with their characteristics of volume, pitch, and *timbre.* This instrument, although so very simple, is capable of doing all that has been done by other instruments of an analogous character, and it will be determined by further experiment whether it will do more. Although carbon contact points are preferable, they are not absolutely essential to the operation of the instrument, as metallic points will do the same things, but not so satisfactorily."

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ELECTRIC ILLUMINATION.

I.—Production of Electricity.

It is now sixty-five years since a remarkable discovery was announced by Sir Humphrey Davy. In 1813 this philosopher had constructed, in the laborartory of the Royal Institution in Albemarle-street, a powerful voltaic battery of 2,000 zinc and copper couples, in order to study the decomposing effects of electricity on various substances then supposed to be simple bodies. The result was the discovery of potassium and other metals of the alkalis, and alkaline earths. In the course of this investigation Sir Humphrey had occasion to employ charcoal terminals for his battery. He was astonished to find that, when the charcoal points were brought into contact, and then separated to a certain distance, the electric current continued to pass in the form of a luminous arc of dazzling brilliancy. As the current employed by Davy was due to a high electromotive force, the length of the arc obtained was nearly four inches. This remarkable result, which created a great sensation at the time, remained for the next thirty years little more than a brilliant lecture experiment. No attempt seems to have been made to utilise it; indeed, the means of producing electricity in those days were so imperfect that a battery could hardly be relied upon for more than ten minutes at a time, owing to a phenomenon called polarisation. The inconvenience caused by polarisation was ultimately removed by Professor Daniels' invention of the so-called constant battery, which is still used to some extent for telegraphic purposes. Daniels' battery, though very constant in its action, is not one of great power, and the first idea of using the electric arc as a source of light practically dates from the invention of the nitric acid battery by Grove and Bunsen.

The pioneers of electric illumination were Deleuil and Léon Foucault, the former of whom experimented in 1841 with pieces of wood charcoal arranged in an exhausted receiver. Foucault, in 1844, by employing pieces of the very hard coke which is found deposited on the walls of gas retorts, obtained vastly better results, and the light gained in this way was far more manageable.

As the result of Deleuil's and Foucault's experiments, the electric light made its first appearance on any stage at the Opera House in Paris in 1846, when it was employed in "Le Prophète" with great success to represent the rising sun.

It was soon found that this application of electricity was attended by great difficulties and inconveniences.

To begin with, it was very expensive.

Secondly. The batteries were nasty things to handle. They were charged with strong and corrosive acids, and, although much more constant in their action than the old batteries used by Davy, they could not be relied upon after three or four hours' use.

Thirdly. The carbon rods, between which the light was produced, gradually burnt away, and required continual readjustment to prevent the light going out; indeed, it was found that the slightest variation in the distance which separated the two points caused the light to fluctuate to a surprising extent, so that, with the most careful adjustment, the light was extremely unsteady.

Fourthly. The light proceeded almost from a point. The shadows were tremendously dark and sharp, producing a curious but most unpleasant effect. The light was all in one place, as it were, and could not be distributed. Everything in the neighbourhood of the lamp was intensely illuminated, while objects more remote were, by the mere force of contrast, lost in pitchy darkness.

It will be our business to inquire how far these difficulties and inconveniences have been overcome, and what chance the electric light in its present condition, as used in Paris and elsewhere, has of superseding or competing with gas as a practical means of illumination.

Although the voltaic battery was the starting point of the electric light, and practically regulated its cost, no improvement worth talking about in relation to this application has ever been made in it. The nitric acid battery remains what it was at first, a most inconvenient piece of physical apparatus, but the most powerful battery we have, and perhaps the only one at all suited for the production of the electric light. It is perfectly certain that, if the world had remained dependent on voltaic batteries as the sole source of electricity, the purposes to which electric illumination could be applied with advantage would have been very limited, notwithstanding the more or less complete way in which the other difficulties have been surmounted. It would have been suitable only for theatrical and military purposes, for the magic lantern, for quite exceptional illumination of large public works, and for *fêtes* and rejoicings, as a sort of scientific fireworks—for purposes, in fact, where cost was a matter of little moment. For anything else, it was far too troublesome and expensive, and it was not sufficiently trustworthy to be employed in lighthouses, for which the electric light was eminently fitted by some of its qualities.

In July, 1820, seven years after the discovery of the voltaic arc, another discovery was made, not at first sight so brilliant in its character, but probably the most important of the present century—the connection between magnetism and electricity. Professor Oerstedt, a Danish physicist, observed that the magnetic needle was affected by a wire through which an electric current was passing—that the needle, in fact, set itself invariably at right angles to the direction of the current. This experiment, like Davy's, remained an observation without practical application for a number of years, although it was, in fact, nothing less than the discovery of the electric telegraph, amplified afterwards by Wheatstone and Cooke into the well-known needle instrument. Oerstedt's experiment was supplemented in September of the same year by the discovery of electro-magnetism, by Arago, who found that a bar of soft iron, around which a current of electricity was caused to circulate, was converted into a powerful magnet, a property which it lost directly the current was interrupted. No further progress was made during the next ten years, until, in 1830, Faraday, working in the same laboratory in which his teacher, Davy, had first produced the electric light, made a discovery upon which the present economical production of electricity is based. Faraday, following up the observations of Oerstedt and Arago, found that not only does an electric current induce magnetism in a bar of iron brought within the sphere of its action, but that a magnetic bar, when brought near a copper wire, sets up in the latter an electric current. In one word, electricity is convertible into magnetism, and magnetism into electricity. He remarked that, when a magnetised bar of steel was thrust into a coil of copper wire, an electric current was developed in one direction, and when it was withdrawn a current was set up in the reverse direction. It had long been known that a permanent steel magnet has the power of temporarily impressing its magnetism upon pieces of soft iron brought into its immediate neighbourhood, and this suggested a modification of Faraday's experiment. If a bar of soft iron is left permanently in the coil, and this bar is alternately magnetised and demagnetised, by the approach and withdrawal of a permanent steel magnet, practically the same effect is produced as when the steel magnet itself is thrust in and drawn out.

On this principle, Pixii, in Paris, and Saxton, in London, constructed, in 1832, the first machine for generating electricity. A bar of soft iron of a horseshoe form was covered with insulated copper wire bound round it, always in the same direction. This arrangement was placed end to end opposite a permanent steel magnet, also of a horseshoe form, in such a way that the poles of the soft iron horseshoe were almost in contact with the poles of the magnet. One was then caused to revolve in front of the other, which was fixed so that at each half revolution the magnetism set up in the soft iron was reversed. In this way, alternate electric currents, first in one direction, then the other, were set up in the wire surrounding the soft iron.

The principles of the two machines were indentical, but Pixii caused the magnet to revolve, and Saxton the soft iron core. This apparatus, with very little modification, is still employed to furnish the electricity for Wheastone's alphabetical telegraph, so much employed for private purposes, and is, in fact, almost identical with the rotatory medico-galvanic apparatus which may be seen in every druggist's shop.

A machine, therefore, existed forty-five years ago by which electricity could be produced, whenever required, by using the motive power necessary to cause the apparatus to revolve. However, the quantity of electricity produced by these primitive arrangements was so small that no one appears to have suspected at first that, as sources of electricity in quantity, the machinery could in any way replace the battery. The ingenuity of inventors was, indeed, exercised in exactly the opposite direction. The enormous attractive force of large electromagnets, a power which can be called into existence in a moment, and be made to disappear at will, soon suggested the possibility of a new motive power. Numberless electro-motive engines were invented, and worked with more or less success. Jacobi, of St. Petersburgh, and Page, an American experimenter, constructed engines of this sort on a considerable scale, and much money and more ingenuity were wasted in this vain pursuit. It became an article of popular belief that steam had had its day, and must now give play to the new agent, electricity. Like most popular scientific notions, this was utterly wrong, and was, indeed, the exact reverse of the truth. So far from electricity dethroning the steam engine, the steam engine was soon destined to furnish torrents of electricity at one-fiftieth part of the cost of that battery electricity which was then looked upon as its dangerous rival.

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The first magneto-electric machine constructed on a large scale appears to have been made by Nollet, of Brussels, and it is remarkable that Nollet was impelled to its construction by the pursuit of a chimera quite as preposterous as the endeavour to supplant steam by electricity. His object was to decompose water by electricity, obtained as cheaply as possible, and then with the oxygen and hydrogen so obtained to light the steels with the oxyhydrogen lime light. His machine consisted of a number of steel magnets, aranged on annular supports, between which turned other rings furnished with induction bobbins—that is to say, small, short bars of iron, around which coils of insulated copper wire had been wound. A great deal of money was wasted in this enterprise, but the machine remained to demonstrate the possibility of producing large quantities of electricity with a comparatively small expenditure of motive power. Nollet's machine, subsequently improved by Van Malderen, was ultimately taken up and manufactured by the "Société Alliance," and is even now employed in many of the French lighthouses. Another machine was constructed by Holmes, of London, in which the magnets revolved, and the coils were fixed. This machine was constructed expressly with a view to the electric light, and was adopted by the Trinity House.

The first most important stride in the construction of the modern magneto-electric, or, as it is now called, dynamo-electric machine, was made by Wilde of Manchester in 1860. It had been remarked that the electricity produced by a magneto-electric machine would, if passed through the wire of an electro-magnet, develope far more magnetism than was contained in the magnet from which the current itself was produced. Applying this fact, Wilde constructed a small magneto-electric machine with permanent magnets, and directed the current obtained from it through the wire coil of a large electro-magnet. This electro magnet replaced the comparatively feeble permanent magnet of the older machine, and the quantity of eclectrity produced was enormous. Instead of using a number of little bobbins, as in the machines of Nollet and Holmes, Wilde adopted a form of induction armature which had been proposed by Siemens in 1854. This consisted of a bar of iron, caused to revolve on its long axis between the poles of a number of magnets side by side. Over this bar of iron an insulated copper wire was wound, not round it, but endways, like the thread on a knitting needle. Instead of the permanent magnets placed side by side, as used by Siemens, Wilde used his electro-magnet, but constructed it of iron plates, so as to present a pair of long thin poles, between which the long Siemens armature revolved. This machine was the most powerful source of electricity which had then been produced. A 12-horse power steam engine was required to drive it, and the electricity developed far exceeded that of the most powerful batteries. In the following year Wilde's machine was simplified and improved by Ladd of London. When an electro-magnet has once been excited, it never quite loses all its magnetism, possibly owing to a little steel which the soft iron contains; there is always a certain amount of what is called residual magnetism. It occurred to Ladd that the residual magnetism would be sufficient to start the generation of electricity, and then that the electricity so developed might be passed into the electro magnet, whose magnetism thus increased would send on the revolving armature, and in a way generate all the power required, without having recourse to the permanent magnet at all. This expectation was completely realised. Ladd constructed a machine similar to Wilde's, but without the smaller arrangement of permanent magnets. It was furnished with two Siemens' armatures, one large, the other small. The smaller one generated, first from the residual magnetism of the electro magnet, and afterwards from its full power, the electricity requisite to maintain the magnetism, while the larger armature generated electricity available for any other purpose. This, then, was the first purely dynamo-electric machine. The permanent steel magnets were got rid of. The action was not so much the conversion of magnetism into electricity as the conversion of mechanical into electrical energy.

All these machines were attended by certain inconveniences. The current of the voltaic battery always proceeds steadily in one direction, but, as we have already explained, this is not the case with magneto-electric or dynamo-electric machines. At every change in the magnetism of the iron core of the revolving bobbins, or armatures, two currents are produced, one from right to left, succeeded immediately by one from left to right. In order to arrange these currents and convert them into one continuous current, always moving in the same direction, it is necessary that the ends of the wires which receive the electricity and convey it from the machine should be reversed at each change. This is effected by a contrivance called a commutator, placed upon the revolving axis of the armature, which automatically accomplishes this object. For certain purposes this is absolutely essential; for example, electro-plating. The most powerful alternating currents would produce absolutely no effect whatever in the plating bath, what is done by the current in one direction being exactly neutralised by the subsequent opposed current. For the purpose of the electro-light, this is, under certain circumstances, of less importance; and, in one instance, the Jablochkoff candle, the alternating currents are to be preferred.

Another inconvenience is that currents of electricity are also set up in the rotating pieces of soft iron, as well as in the wires that surround them, and under such circumstances that the iron has a tendency to become exceedingly hot, frequently rendering a stoppage of the machine necessary. This has been most ingeniously avoided by Von Alteneck, of the firm of Siemens and Halske, Berlin. In his arrangement, the iron core remains motionless, while the coil of copper wire rotates round it, and between it and the poles of the electro-magnet.

To Gramme, of Paris, is due the credit of constructing a machine of great simplicity, giving at once, without the use of commutators, a powerful and continuous current of electricity. In the ordinary machine, the armature, a bobbin with the whole of the wire wound round it, is alternately submitted to the action of the north and south poles of the magnet, and alternating currents result. Going back to Faraday's experiment, it will be recollected that while the bar in the coil is undergoing magnetism of either kind the current is in one direction, it is only when it is being demagnetised, or when the magnetism is reversed, that the reverse current is set up. Now, if the current is only taken off while the magnetism is going on, the current will be in one direction only, and, if one coil after another containing an iron bar is submitted to the action—say, of a north pole of a magnet, and the current is taken off only during the time of presentation, the current will always be in the same direction. What amounts to the same thing is to use a long bar, around which are wound independent coils, which are passed one after the other across the pole of the magnet. In order to accomplish this, Gramme constructed an iron ring, around which he wound, side by side, independent coils of insulated wire. As each succeeding coil came into the magnetic field, he collected the electricity developed, and, as the coils, at the moment of collection, were always under the same circumstances, the current was continuous, and always in the same direction. The whole of the current evolved is made to pass round the electro-magnet before being employed elsewhere. At the same time, a number of minor inconveniences of the old machines, into which we have not space to enter, are got rid of; the machine is so sensitive that no residual magnetism is required, the magnetism of the earth being sufficient to start the action. Hardly had Gramme brought his continuous current machine to perfection, than he found himself obliged to retrace his steps, and construct a machine with alternating currents. Quite recently, the Jablochkoff electric candle, which presents certain advantages in particular applications of the electric light, has come into somewhat extensive use. This apparatus, for reasons to be described afterwards, will not work with direct continuous current. The machines of the Société Alliance, which give alternating currents, were not thoroughly satisfactory, and Gramme set himself to work to supply the want. In his new machine he still adheres to his idea of the ring, round which are wound a number of independent coils, but he makes the ring of larger dimensions, and it is fixed. Following out the plan of Holmes, it is the magnets which revolve. In the centre of the ring is fixed a shaft upon which are placed radially bar electro-magnets (usually eight) so arranged that the north and south poles alternate. As the shaft revolves the coils on the outer ring are submitted alternately to the two magnetic influences, and alternating currents are produced. The electro-magnets themselves are excited by a small Gramme machine giving continuous currents, and driven by a belt from the same steam-engine which drives the principal machine. As the magnets on the shaft and the coils on the ring are arranged symmetrically, it is clear that a certain proportion of the coils, at any given time, must be in the same electrical condition. It is, therefore, possible to deal with the coils in different groups, so that a number of independent currents may be taken from the machine, or they may be united for quantity, or coupled up in tension like the cells of an ordinary battery. Besides Gramme's machines, several others have been lately constructed, notably two by Lontin, one for continuous, the other for alternating currents, in both of which separate bobbins are employed. The apparatus for alternating currents bears some analogy to a later form of Holmes' machines, in which electro-magnets were substituted for the permanent magnets originally used. We have also seen a description and drawing of an American machine, the so-called Brush machine, which is said to work well, and is, if it does all that is claimed for it, certainly the cheapest machine in the market. It is not our business to decide which is absolutely the best and most perfect

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machine yet made. For continuous currents the Gramme machine seems to bear away the palm for simplicity, lightness, and small motive power required. The Gramme machine for alternating currents appears to work exceedingly well, but, as it is of very recent invention, it is too early to pronounce on its practical performance.

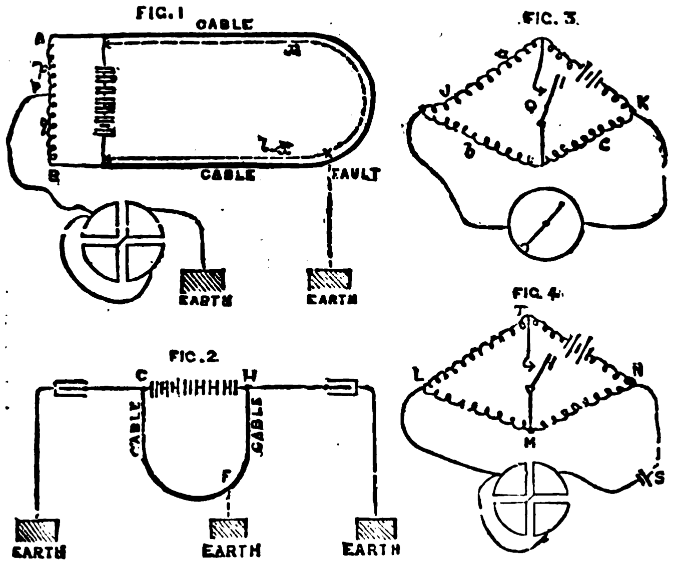
ON THE EMPLOYMENT OF AN ELECTROMETER WITH A WHEATSTONE'S BRIDGE.

By W. E. Ayrton and John Perry.
Professors in the Imperial College of Engineering, Tokei, Japan.

In testing with a Wheatstone's bridge, two points at the same potential have to be experimentally found, one in one circuit, and the other in another circuit. This may be done either with a galvanometer or with an electrometer; but, as a rule, a galvanometer is always employed, since the galvanometric method is usually far more sensitive. There are two cases, however, to which attention has not been specially drawn, in which the employment of an electrometer will lead to far more accurate results than could be obtained by using a galvanometer.

First.—When determining by means of the loop test a *very small* fault in a short piece of cable. Here, since the resistance of the fault is extremely great, many megohms perhaps, but a small current will flow into the cable if the fault be introduced into the battery branch; or, if it be introduced into the galvanometer branch, then the galvanometer current will be small, even where the adjustments of the resistances are far from those that give balance.

But if the connections be made as in the accompanying fig. 1, and by means of an electrometer, a point P be found in the resistance coils A. B, having the same potential as the cable tank, or the point F in the cable where fault exists, the delicacy of the test will be practically independent of the resistance of the fault, and, therefore. for *very small* faults will far exceed that obtainable with a galvanometer.



And, again, since the method is a null method, it will give far more accurate results than can be obtained by that of Mr. Latimer Clark, which consists (see Clark and Sabine's Electrical Tables, page 59) in measuring the potentials at the two points G, H, fig. 2, by means of taking discharges of condensers of known capacity, charged by connecting them respectively with the two points G and H, and using the well-known equation

$$\frac{\text{resistance of G F}}{\text{resistance of H F}} = \frac{\text{potential of G}}{\text{potential of H}}.$$

If there be an electromotive force e in the fault, then this cannot be altered by the method of testing shown in fig. I., since whether P and F are at the same potential or not, practically no current passes through the fault. To find the position of F when there is an electromotive force in the fault, let p, q be the resistances of the two portions of A B that produce balance when the battery is in the position shown in fig. 1, and let e be equal to the difference of potentials of two points in the coils A B, separated by a resistance s, then

$$\frac{x}{l - x} = \frac{p + s}{q - s}$$

if x is the resistance A F, and l the resistance of the whole loop. When the testing battery is reversed, let p' q' be the resistances of the two portions of A B that produce balance, then

$$\frac{x}{l - x} = \frac{p' - s}{q' - s}.$$

$$\therefore x = l \frac{p + p'}{p + p' + q + q'}.$$

Second.—When determining the resistance of a battery, by Mance's test, we have to adjust the resistances a, b, c, fig. 3 until the same current passes through the galvanometer joining J K, whether or not contact is made at Q, that is until the difference of potentials between J and K is the same whether or not contact is made at Q. Mr. Lodge* in a paper in the supplementary number of the "Philosophical Magazine," for June, 1877, shows fully why the galvanometer method, not being a null method, is an unsensitive one, and he suggests the introduction of a condenser into the galvanometer branch, so that any variation of the difference of potentials between J and K, produced on closing Q, will alter the charge in the condenser, and so produce a transient current in the galvanometer deflecting the needle from zero. But if balance were nearly attained, and if for example the closing of Q only changed the difference of potentials between J and K by the hundredth part of a volt or less, then it would require either a very large condenser or an extremely delicate galvanometer to detect it; whereas if an electrometer and compensating battery S, fig. 4, were employed, and a point M sought for in the circuit L M N, such that making contact between M and T no deflection of electrometer needle is observed, the arrangement would be extremely sensitive. We would, therefore, suggest this as an improvement on Mr. Lodge's proposal.

The object of the battery S is to bring all four quadrants to the same potential when M and T are not in contact. As it sends no current, it cannot alter the electromotive force or resistance of the battery under test. As the resistance L M N and L T are not varied, but only the ratio of L M to M N, no adjustment of the battery S or of the electrometer need be made during testing. Of course, it is not necessary that S should bring all four quadrants to exactly the same potential, all that is required is that the electrometer needle should be kept permanently near its zero position when contact is not made between L and N, so that the electrometer may be adjusted as sensitively as we please.

Instead of a quadrant electrometer a capillary electrometer, with or without the compensating battery S, may be employed, and with such an electrometer one ten-thousandth of a volt (according to Mr. Dewar) can be measured. Now, the charge produced by such an electromotive force in any ordinary condenser is immeasurable on any ordinary galvanometer.

The Use of Condensers with the Electric Light.—M. P. Jablochkoff has successfully applied condensers of very large surface to distribute to several points the electricity derived from one source, having in view such application to the requirements of electric lighting. He has generally worked with machines giving alternate currents. The condensers employed were made of metallic sheets, separated by glass, or some other insulating material. As an example of his experiments, he says, with a machine giving alternate currents, capable of giving a spark similar to that obtained from six or eight Bunsen elements, by interposing a series of condensers, having a surface of about 500 square metres, he obtains a voltaic arc of from 15 to 20 millimetres, and carbons of 5 mm. dia. were rendered red hot for a distance of from 6 to 10 millimetres from their extremity.

Edison's Carbon-Compression Relay.—This apparatus, constituting an interesting application of the now well-known variability of the resistance of charcoal under compression, is composed simply of a small box, of which the sides are of ebonite, or other non-conducting material, and the bottom and lid of soft iron—this "lid" being small enough to be contained within the box when this is empty. This box is more or less filled with charcoal powder, and is then placed as an armature over the poles of an electro-magnet in the line circuit. The local circuit is completed through the soft iron plate forming the bottom of the box, the charcoal powder contained within the latter, and the soft iron lid. When no current passes in the line circuit, the resistance in the local circuit is so great that the instruments included in it are not affected by the small current passing from the local battery. But, when a current traverses the electro-magnet in the line circuit, the carbon powder is compressed by the attraction between the two soft iron plates constituting the armature, and the resistance of the local circuit is sufficiently diminished to allow of the working of the instruments by the local battery.

* This Paper has been reprinted in our columns, *vide* pp. 136, 159, and 172.

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THE SOCIETY OF TELEGRAPH ENGINEERS.

"What a pity it is that no contrivance should be adopted for concentrating the knowledge that different individuals attain in this art into one common focus, if the expression may be admitted." So wrote, a century ago, a philosopher whose words all electricians should respect. But, if Dr. Franklin had lived now, he would have no cause to complain of any want of *foci* for the various branches of knowledge. Every subject now, mushrooms and microscopes not excluded, has its Academy or its Peripatetic school of devoted students. There are probably few of our readers who do not belong to some of the various Societies, Institutes, Associations, and the like bodies which abound all over the country for the promotion of learning and research, from the time-honoured Royal Society, whose membership is, in the scientific world, as a title of nobility, down to that humble but famous Mutual Improvement Club of a Scotch village, which undertook to discuss the question, "*Shall* the material universe be eventually destroyed?" and, after due consideration, solemnly decided that, so far as their opinion went, it should not.

The season of Conferences, Congresses, and such nomadic gatherings is almost over; and the shortening evenings remind us that the season is drawing on for the ordinary humdrum meetings of our learned societies, at which so much valuable work is done in a quiet way. We shall, as hitherto, consider it our duty to give reports of those parts of their proceedings which may be of interest to the electrical world. Our science receives occasional attention from the Royal Society, the Physical Society, the Chemical Society, the Society of Arts, and others; but the body with which we have most to do is, of course, the Society of Telegraph Engineers. The name of this young but vigorous fraternity has an unpretending sound, which would please that enlightened parent who, on bringing his son as a pupil to a certain professor, remarked, that he did not wish the boy to learn anything about oxygen and hydrogen, or any such stuff, but to get "a good, sound, practical knowledge of chemistry." But our society is something more than "practical," in this sense of an often-abused word. There is no want of really sound and deep science in a body that has such a president as Dr. Siemens, or such members as Profs. Adams, Ayrton, Thomson, &c. As the old Electrical Society has never been resuscitated, the Society of Telegraph Engineers is, in fact, the "focus" of telegraphic science; and no one who knows what its work is can deny that it plays its part as worthily as if it assumed a more comprehensive and pretentious title.

May we, then, be pardoned if our zeal for the cause in which it has done so much prompts us to suggest an extension of the work of this society? Why should it not concern itself more directly with the education of students of electricity? This reflection has been forced upon us by a letter from the United States, inquiring what means of instruction are offered in this country to a telegraphist who wishes to make himself master of his art, and what would be the expense of such instruction. We can give no encouraging answer to our correspondent. What he requires is only to be had from private schools or teachers, at considerable expense, or in the office of a company, where the training cannot but be hasty and empirical. Universities may be left out of the question, as few of the students whom we have in view can avail themselves of a University curriculum. We published in a recent number an account of the Government School of Telegraphy, but the teaching there scarcely goes beyond mere manipulation, besides, of course, being inaccessible to private students. South Kensington will furnish them with lectures and certificates, which are all very well as far as they go. But there is nothing answering to Professor Frankland's chemical laboratory at South Kensington, where the electrical student might obtain a thorough practical and theoretical knowledge of his work, and, as yet, no professional body has undertaken to do for us what lawyers, doctors, actuaries, and other professions do for their neophytes.

The Society of Telegraph Engineers appears to be clearly fitted to fill this vacant place, even if it were only, as a commencement, to the extent of holding examinations and issuing certificates of competency. But we do not see why they should not offer lectures, with the use of books and apparatus, to young electricians. The expense may be objected. We have reason for saying that the teaching desired might be given gratuitously, for a time at least; and, even if a fee were required from the students, it need not be nearly so high as the charges of private instructors, not all of whom can offer in return such scientific ability and such complete apparatus as the Society has at its command. Many parents are now anxiously looking about for a promising occupation for their sons; they might think more favourably of telegraphy if such a competent body undertook to prepare young men for this line of life, into which so many men at present find themselves without being able to say how or why they came there. The principle of natural selection would thus be brought to bear on our profession, as we insist on calling it, to its no small benefit. And the profession would bulk much more largely in the public

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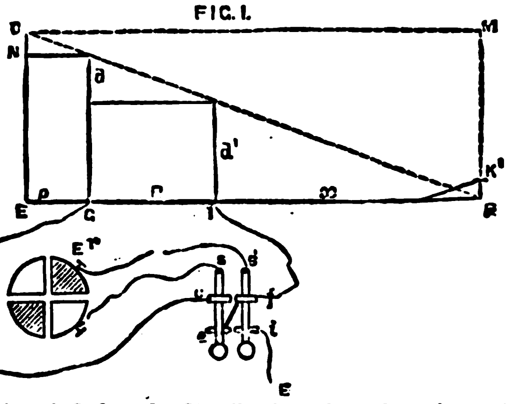
eye if an influential society were recognized as occupying the some position towards it as, for instance, the College of Physicians and the Institute of Actuaries do in their respective fields of action.

We trust, therefore, that this Society will take this question of education into its serious consideration. Without going so far as the enthusiasts who prophecy that, in a generation or two, every scion of a civilised country will have to learn how to handle electricity as much of course as to know the alphabet, it is evident that there is already, and will soon be still more, a demand for electrical teaching. The Society of Telegraph Engineers would be but claiming its due position, as well as conferring a benefit on the public at large, if it came forward betimes to meet this demand, and thus put itself at the head of whatever is doing in the science which forms its *raison d'être*. And, for ourselves, we may conclude by finishing the quotation from Dr. Franklin with which we commenced this article:—"Our endeavours shall not be wanting to collect together, in the best way we can, the scattered hints that shall occur under this head."

A NEW METHOD FOR DETERMINING THE CURRENT ELEMENTS OF A VOLTAIC CIRCUIT.

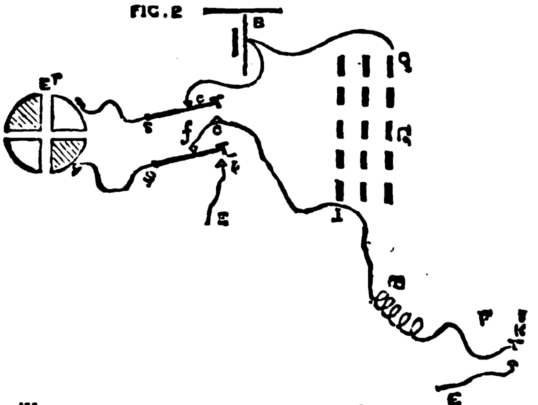
A plan for quickly determining all those values which are known as the "current elements" has long been a desideratum. Hitherto the connections have had to be altered, and even altogether different apparatus employed, in carrying out the various tests. The desideratum in question has now been supplied by a new series of tests—including the determination of the intensity of the current, the electro-motive force of the source, the external resistance of the circuit, the internal resistance of the battery, and, finally, the degree to which the latter has become "polarised"—which has been devised by Mr. Desmond G. Fitz-Gerald, and which involves a key of novel construction, to which the name of "shifting contact key" has been applied, because it is so arranged as to transfer the contacts, by its depression, from one part of the circuit to another. The electrometer is the instrument of precision used in the tests.* The theory of this system is illustrated by the diagram, Fig. 1. The fall of potential taking place over any given resistance in a circuit is, *cœteris paribus*, proportional to the resistance; therefore, if we know what is the fall over a given resistance, we can easily calculate the resistance proportional to any other fall indicated by a suitable instrument. The application of this principle, by means of which the external resistance and internal or battery resistance are measured, is not in itself novel; the novelty in the present system of testing consisting mainly in the convenient arrangement of a number of tests, so to speak, into a small compass.

FIG. I.



Bearing in mind that the distribution of tensions in a circuit, after the normal statical conditions have been obtained, is represented, in the case of an insulated circuit, by two triangles, and, in the case of a circuit where the negative pole of the source is connected to earth, by a single triangle of the form D E F (Fig. 1). Let E F represent the sum of the resistances in a circuit, and E D the electro-motive force acting in the circuit; then E G = ρ will be the internal resistance of the source, G I = R may be taken as a known, or *unplugged* resistance, and I F = x as an unknown wire resistance in the circuit. The positions in the circuit of the elements of a single couple are indicated at E and G, the positive element at E being connected to earth, so that E D represents the potential of the layer of fluid in immediate contact with this element. It must also be borne in mind that, before the key k^1 is depressed, the tension in the circuit will be everywhere the same, and is represented by the parallelogram E D M F. The key k^1 is inserted at some point in the circuit, so that the electro-motive force E D, or what we call deflection D, may be obtained while the circuit is broken.

FIG. 2



We will now proceed to describe the different methods of obtaining the several deflections, &c.:—

Test 1. Maximum potential or electro-motive force = deflection D. It will be seen from Fig 1, in which E represents the positive element of the source connected to earth, that, on depressing the right-hand spring s^1 of the main key, one pair of quadrants of the electrometer, E^r, is connected to earth, and, as E is also to earth, the quadrants are virtually connected to E; the other pair of quadrants being connected, through the spring s, with G. Now, the key k^1 being up, we obtain a deflection D, which is the maximum potential or electro-motive force of the source; in fact, we obtain E D. But D is only a certain number of degrees on a scale, and we require to know the electro-motive force in volts; therefore we must know the number of degrees that a standard of a known value in volts will give on the same scale. Suppose we have decided to use Mr. Latimer Clark's standard element, having an electro-motive force = 1·457 volt; suppose also that this element gives a number of degrees = D^1; then we have the proportion $D^1 : 1{\cdot}457 :: D : E$, from which proportion the required electro-motive force is

$$E = 1{\cdot}457 \frac{D}{D_1} \text{ volts.}$$

Test 2. To determine the unknown wire resistance x. In this test k^1 must be depressed so as to close the circuit, when the potential will fall proportionately to the different resistances in the circuit, as shown by the line D F. Now, when k^1 is depressed and the connections are as in Fig. 1, we have on the electrometer the deflection corresponding to the fall of potential over R, the known resistance. Let us call this deflection d. Now, all that has to be done to obtain x is to depress s and s^1 together, whereby the electrometer contacts are transferred from G and I to I and earth, and, F being to earth, the contacts are really transferred to I and F. We, therefore, now have indicated on the electrometer the deflection corresponding to the fall of potential over x. This deflection let us call d^1; now, as we know d and R and d^1, it will be easy to calculate x from the very evident proportion $d : R :: d^1 : x$; thus $x = R\dfrac{d^1}{d}$. We have now obtained the electromotive force and x; we have still to obtain ρ, and when this is obtained we have all the materials for the equation for the intensity of the current, viz., $I = \dfrac{E}{R + \rho}$.

Test 3. To obtain the internal resistance (ρ) of the battery. We can get no deflection to represent the fall of potential over ρ, because the only way of obtaining it directly would be by putting a negative plate as near as possible to the zinc in the fluid—in fact, by making the resistance of the battery *nil*. We must, therefore, obtain it indirectly. It will be seen by Fig. 1 that D N is the actual fall of potential over ρ, and it will also be seen that the value for D N may be arrived at by subtracting d and d^1 from D, thus $D - d - d^1 = D N$. Now, if we could arrive at this result directly, this would represent the deflection corresponding to the fall of potential over ρ; and ρ is found, from the proportion $d : R :: D - d - d^1 : \rho$, to be $\rho = R\dfrac{D - d - d^1}{d}$.

A point which is now recognised as of very great importance is

* A condenser and galvanometer may be used in lieu of the electrometer; the "throw" of the needle being observed when the condenser is charged or discharged.

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to obtain the values from which the internal resistance may be calculated without circuiting the battery for a sufficient space of time to allow of any "polarisation" taking place. It is frequently desirable, in fact, that the battery should not be circuited for a period of time exceeding one second before obtaining the electrostatic charges on which these values depend. The plan recommended in order to obtain the real resistance of the battery with the greatest accuracy is, first, to depress k_1; secondly, instantly to bring the springs s and s_1 between the stops; and, thirdly, to release k_1. It is frequently advisable to use a small condenser in combination with the electrometer, its terminals being simply connected respectively to the two sets of quadrants.

We have now all that we require in the equation $I = \frac{E}{R + \rho}$, and, therefore, can calculate the intensity of the current.

To obtain the degree of "polarisation" of the battery; calling ϵ the electro-motive force of the battery when the circuit has been closed any given period of time, it is evident that, if the "polarisation" be *nil*, $\epsilon = E$; but, if "polarisation" has occurred, $E > \epsilon$, and the exact value of the latter as an electrical deflection may be calculated from the proportion, $x : d^1 :: \rho + R + x : \epsilon$. Thus

$$\epsilon = \frac{(\rho + R)\, d}{x} + d^1,$$

and the "polarisation" is measured by $E - \epsilon$.

The construction of the "shifting contact" key will be understood in a moment by referring to Fig. 1, from which it will be seen that the key is somewhat similar in appearance to an ordinary reversal key, the difference being that the lower and upper contact pieces, instead of being the same for both springs, are cut through and insulated. There is one other difference, viz., the upper contact piece of the right-hand key is connected to the lower contact piece of the left-hand key. Fig. 2 is a diagram showing the practical arrangement of the instruments employed in these tests, the lettering being the same as Fig. 1.

The "Shifting Contact Key" by means of which the above tests are carried into effect may be obtained of Messrs. Elliott Brothers, of Charing-cross.—*Engineer.*

ON TELEPHONY.

By W. Siemens.*

[CONTINUED FROM P. 195.]

This sensitiveness of Bell's telephone to feeble currents renders it very useful as a galvanoscope, especially for the detection of feeble and rapidly changing currents, for which there has hitherto been scarcely any other means of testing than the contractions of the leg of a frog. Also, in measuring resistances by the bridge method, the telephone may often be employed with advantage instead of the galvanometer in the branch wire of the bridge; but then it will be necessary to employ as resistances only straight wires stretched at a greater distance from each other, as otherwise perturbations would arise through induction.

This perfectly explains the extreme sensitiveness of the telephone to electrical disturbances in the conductor, which, indeed, almost entirely excludes its application to lines above ground if the same posts support wires which are used for telegraphic correspondence. Even when two neighbouring conducting wires on the same posts are employed to form the conduction-circuit, in which case the electrodynamic as well as the eletrostatic induction proceeding from the other more distant wires is in great part compensated, still every current that passes through these wires is heard in the telephone as a loud cracking noise rendering the speech of the telephone quite unintelligible if it is frequently repeated.

Far worse still are these disturbances if the earth is used for closing the circuit. Even when special earth-plates are taken for the telephone-wire, or if gas or water-pipes are made use of for the same purpose, every current is distinctly heard which is brought to earth through earth-plates in the vicinity. Since, in the spreading of a current in the ground, the electric potential diminishes with the cube of the distance from the point at which the current enters the earth, this also demonstrates the uncommon sensibility of the telephone to feeble currents.

For these reasons, with overland conducting-wires telephones can only be employed if special posts are appropriated to the support of the wires. Further, the earth's conduction can only be used in places where there are no telegraph-stations, or where the earth-plates used for telegraphing are at a good distance from those which serve for the telephone-conductions.

Notwithstanding this sensitiveness of Bell's telephone, it conveys but very imperfectly the sound-waves by which its membrane is struck to the corresponding membrane and the ear applied to it. When a loud-ticking watch was placed close to the sound-aperture of a very sensitive telephone constructed after Bell's plan, the ticking could not be heard in the other telephone, even when the watch actually touched the telephone-case. On the other hand, the above-mentioned thread telephone transmitted the ticking through a thread about 20 metres long very distinctly; it was still audible when the ear was withdrawn 8 centims. from the mouth of the hearing-tube. The ticking could be heard direct with about equal distinctness at the distance of 130 centims.; consequently, the thread telephone conveyed about $\frac{1}{250}$ of the intensity of the sound. Since the electric telephone transmitted the softest speech intelligibly, it must be on account of the rapid and irregular vibrations which form the toneless, even if louder, noise of the ticking, that it cannot transmit the latter.

From a like cause a proper, perfectly toneless whisper cannot be understood through the electric telephone, while through the thread telephone it is distinctly intelligible to a distance of 20 metres. Just so electric telephones, which reproduce the softest speech distinctly, do not convey at all, or scarcely perceptibly, the loud but toneless clap of two pieces of iron or glass struck together.

It is remarkable that the electric telephone, in spite of this almost incapability of conveying the noises which consist of rapid and irregular vibrations, yet so truly renders the quality of musical tones and the sounds of speech that the voices of the speakers can be almost as well recognised through the telephone as direct from the speakers themselves. The voice, however, sounds somewhat fuller, which is to be ascribed to the circumstance that the tones are reproduced better and more powerfully than the noises of speech. Singing, too, sounds through the telephone, as a rule, softer and and richer.

In order to gain a fixed point for the solution of the question what fraction of the force of the sound which strikes the membrane of the one telephone is given again by the other, I instituted some experiments with musical boxes. The smaller one, which gave short sharp tones, could be heard by good ears at 125 metres distance upon an open plain, while only isolated tones could be heard through the telephone when it was placed more than 0·2 of a metre from the musical box. In this instance, therefore, only about $\frac{1}{390000}$ of the sound was actually conveyed. A somewhat larger musical box, of not so high a pitch, and giving tones of longer duration, could not be heard in the open air much further than the smaller one; but the telephone at 1·2 metre distance caused the tune played to be recognised. This gives a conveyance of about $\frac{1}{10000}$ of the sound-intensity received by the telephone. Now, although the sounds of speech, as well as deeper and more sustained tones, are probably conveyed better than the melody of the musical boxes, it cannot be assumed that a Bell telephone conveys, on the average, more than $\frac{1}{10000}$ of the mass of sound by which it is struck, to the other telephone.

It follows from the above that Bell's telephone, notwithstanding its surprising performances, effects the conveyance of sound only in a very imperfect manner. That we can understand the speech of the telephone excited by currents so extraordinarily feeble, we owe to the extreme sensibility and great range of our organ of hearing, which enable it to bear the sound of a cannon at five metres distance, and yet to hear it at a distance of fifty kilometres, consequently, to have the sensation of sound from air-vibrations within a range of from 1 to 100,000,000-fold intensity.

Accordingly the telephone needs, and is in a high degree capable of, improvement. Although it is not possible entirely to do away with loss of sound (which would be approximately accomplished if it could be effected that the vibrations of the second membrane should possess the same amplitude as those of the first), since in the repeated transformations of motions and forces there must always be a loss of *vis viva* by conversion into heat, yet the present disproportion is much too great. But by diminishing this loss, and thereby strengthening the arriving sound, we should secure that the hearing would need less exertion, and could distinctly perceive and distinguish the transmitted sounds at a greater distance from the instrument. Then also the perturbations produced by extraneous feeble electric currents would be felt less disturbing, because they would be covered by the more powerful arriving speech-sounds.

Hereby is also given the direction which must be taken for the improvement of Bell's telephone. In order to produce more intense currents, the membrane destined to receive the sound-waves must be sufficiently large and of such a consti-

* Translated from the *Monatsbericht der königlich preussischen Akademie der Wissenschaften zu Berlin.*

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tution that the sound-waves striking its surface can impart to it a maximum of their *vis viva*; while the membrane must be sufficiently movable for its vibrations not to be too small; and the work expended for the production of the electric currents must be so much that the *vis viva* accumulated in the vibrations of the membrane will be consumed by it—or, in other words, so much as to make the membrane-vibrations aperiodic. An enlargement of Bell's iron sheet would be advantageous only within narrow limits, since larger and correspondingly thicker plates are apt to assume vibrations of their own, which diminish the distinctness of the transmitted sounds. It is also requisite that the magnetic attraction of the iron plate in Bell's telephone be not raised too high, as otherwise the plate is too much curved and stretched in one direction, which likewise detracts from the clearness.

I have tried, with considerable success, to strengthen the attraction between the iron membrane and the wire-coiled magnet-pole without bringing the former out of its position of equilibrium, by bringing it between the poles of a powerful horse-shoe magnet.

The pole which was above the iron plate had the shape of a ring, the opening of which formed the sound-hole, while the lower pole of the horse-shoe supported the iron pin with a wire coil opposite to the centre of the sound-aperture. The membrane itself consisted of iron only in the middle, as far as it was opposite to the ring-shaped pole, while the other portion was made of sheet-brass, to which the iron was soldered. Through the action of the magnetic iron ring the middle of the iron plate became itself strongly magnetic; consequently there was a very much strengthened attraction between it and the magnetic iron pin placed opposite to it, while the iron plate, attracted with equal force on both sides, remained, with the whole membrane, in the position of equilibrium, and could, therefore, vibrate freely towards both sides.

Another modification consisted in making both poles of the magnet ring-shaped, and providing them with short notched iron tubes wrapped round with spirals. There were now exactly opposite to the iron plate two ring-shaped magnet-poles of the same kind, while itself possessed the opposite polarity. This is the combination I often employ with good results in so-called polarised relays, in which the moveable, powerfully magnetised iron tongue is situated between two oppositely magnetic poles of a magnet, at equal distance from each, of which the ends are provided with coils.

This arrangement has also been approved for telephonic call-signal apparatus. If a point in the rim of a steel bell, attached to one pole of a horse-shoe magnet, is between two iron pins furnished with coils, which form the other pole of the horse-shoe, a second bell, of the same pitch and with the same arrangement, repeats with surprising force the sound of every stroke made upon the other, if the coils of both are included in a conduction-circuit. The effect is the same with tuning-forks in unison.

Instead of *two* bells or tuning-forks, it is sufficient to insert only one in the telephone-circuit, if the question is only the conveyance of the sound of the bell as an alarm-signal. Telephones then give loud-sounding strokes of a bell.

If in this way the capabilities of the telephone can be considerably heightened, yet, in retaining Bell's iron membrane, we are restricted within rather narrow limits, both as regards the size of the membrane for receiving the sound and the strength of the effective magnetism, an excess of which renders the speech-sounds indistinct and accompanies them with a strange, unpleasant clang.

Hence, for the construction of larger telephones, delivering much more powerful currents, I do not use any vibrating plate of iron, but I fix to the membrane that receives the sound-waves (which is made of non-magnetic material) a light coil of wire which waves freely in a ring-shaped, strongly-magnetic field. By the vibrations of the coil, intense currents, alternating in direction, are induced in it, which, at the other extremity of the conduction, set in similar vibrations either the coil of a similar instrument or the iron membrane of a Bell telephone.

As the breadth of a flat membrane cannot exceed rather narrow limits without confusing the speech-sounds transmitted, by the advice of Prof. Helmholtz I have given to the membrane the form of the tympanum of the ear. This form is obtained, according to Helmholtz, when a moist skin of parchment or a bladder is stretched over the rim of a ring, and then its centre gradually depressed to the desired depth by a screw or otherwise. The membrane will then retain this form after drying. If, now, a model be made after this form, in metal, with its aid a membrane of sheet-brass, or, better, aluminium can be pressed so as to have the same form as the former. Membranes of this shape are especially suitable for the reception of sound-waves and for the transference of their *vis viva* to masses that are to be set vibrating (a purpose which they have to fulfil in the ear also), since their flexion results chiefly near the margin of the membrane—while in flat membranes it takes place more in the vicinity of the centre, and hence, with these, only those sound-waves which strike the middle of the plate come into full action. Such a telephone with a parchment membrane 20 centims. in diameter, a wire coil of 25 millims. diameter, 10 millims. height, and 5 millims. thickness, in a magnetic field of great intensity generated by a powerful electromagnet, transmits with perfect distinctness to a great number of smaller telephones every sound produced in any part of a room of moderate size; and the purity and clearness with which it transmits the sounds of speech and musical notes are remarkable—which may arise partly from the appropriate form of the membrane, and partly from the coil, on moving in the cylindrical magnetic field, generating more regularly sinusoid currents than a vibrating iron plate. An apparatus in which such a wire coil is moved rapidly up and down by means of a winch with a long connecting-rod could be used with advantage for the generation of sine-currents of great intensity.

For giving back the sounds of speech the tympanic form of membrane is not so well suited. It also appears generally more to the purpose to employ larger and more powerful instruments for giving, and smaller instruments of more delicate and lighter construction for receiving, at the same time bringing the instrument into the most suitable position for the ear.

Too powerful receiving-apparatus have the drawback that the counter-currents produced by the vibrations of their membrane weaken the moving currents and displace the trains of sinusoid waves of the induced currects, by which the speech is made indistinct, and assumes strange shades of sound.

It is scarcely to be assumed, generally, that telephones on Bell's principle (in which the sound-waves themselves have to perform the work of exciting the currents required for their conveyance) will be successfully produced, so as to utter speech distinctly intelligible at a greater distance from the telephone; and, as we have already insisted, it is quite impossible of attainment that they should reproduce, not weakened, the mass of sound by which their membrane is struck, or even reinforced. This possibility, however, is not excluded when a galvanic battery is used for putting in motion the membrane of the receiving-apparatus, which then accomplishes the work to be expended. Reis endeavoured to effect this by means of contacts, Edison with the aid of powdered graphite inserted in the conduction circuit of the battery.

Contacts will hardly operate with sufficient constancy and certainty for the sounds of speech to be given back with purity. But it is possible that the solution of the problem lies in the course taken by Edison; it therein only depends on the discovery of a material or an arrangement by means of which changes in the resistance of the circuit may be produced considerable in amount and proportional to the amplitude of the vibrations of the membrane. The form and quality of graphite powder are too variable to accomplish this with certainty. Experiments which I have commenced with other arrangements have not at present given any satisfactory result. Nevertheless, Edison's procedure remains well worthy of consideration, as it possibly forms the key to a future important development of telephony.

If, however, telephonic instruments are susceptible of further extensive improvement, the conducting-lines will always confine the circle of their application within rather narrow limits. Even if, as we have already shown to be indispensable, special posts be appropriated to telephone-lines, carrying no telegraph-wires, and double lines be everywhere employed for the telephones, yet even the telephonic messages on several lines attached to the same posts would soon, with increasing length of the lines, be disturbed one by another, not only through imperfect insulation permitting side currents to pass over to neighbouring wires, but also through the production of secondary currents in them by electrodynamic and electrostatic induction, generating confusing sounds. In telegraph lines electrodynamic induction can, as a rule, be entirely neglected, because it does not increase with the length of the line, if the resistance of the wire coils be left out of consideration, and because the duration of the electrodynamically induced currents is too short to affect the telegraphic instruments; but in telephonic apparatus the brief currents generated by voltaic induction produce very audible sounds if the conducting-lines run side by side for only a short distance.

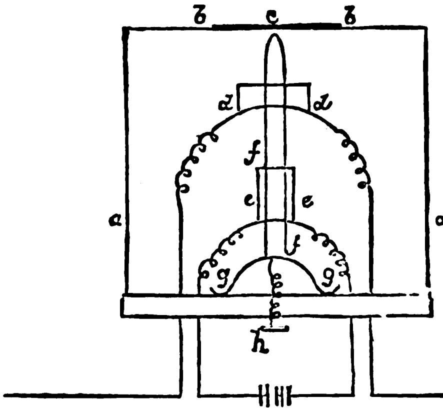
[TO BE CONTINUED.]

NEW ARRANGEMENT OF RECEIVING TELEPHONE

M. Patocchi, Assistant Inspector in the Swiss Telegraph Administration, writes as follows:—

I read, in a Milanese paper, that a professor in Bologna had devised, as a telephonic receiver in connection with the carbon

transmitter of Hughes, an apparatus which allowed several persons readily to hear at the same time the sounds reproduced. The Professor in question, having been kind enough to accede to my request for a detailed description of this apparatus, I was enabled to construct it, and I now send you a sketch of the same :—



a a, forming the outer case, is simply a toy drum six inches high, and the same in diameter.

b b is the membrane forming part of this drum.

c is a vibrating plate similar to that of the Bell telephone.

d d is a coil of wire, of which the terminals are in communication with the carbon transmitter (microphone) of Hughes.

e e is another coil, the terminals of which are connected to a local battery of two elements.

f f is a core of soft iron.

g g a regulating spring, and

h a screw by which the core may be raised or depressed.

With this simple apparatus I have obtained very satisfactory results in a number of experiments. Several persons can simultaneously hear vocal or instrumental music, spoken words, &c., much more distinctly than with the ordinary Bell telephone. The problem of reproducing sound, so as to make it audible at any part of a room, has, therefore, advanced a considerable step towards solution, even if it may not be regarded as already solved.

CORRESPONDENCE.

NEW DISCOVERIES IN TELEPHONY—THE THERMOPHONE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: When the appearance of Bell's Telephone, at the meeting of the British Association in Plymouth, created such universal excitement and wonder, we were apt to think that this instrument would immediately be applied to general practical utility, and replace even its formidable rival, the Morse Telegraph instrument, within a very short space of time.

Experience tells us to-day that the telephone has made very little progress in winning public favour through practical usefulness.

It produces sounds of minimum intensity only; and, as it is liable to frequent derangement, and, therefore, wants constant attention, we fear it will soon pass over to the long list of scientific toys.

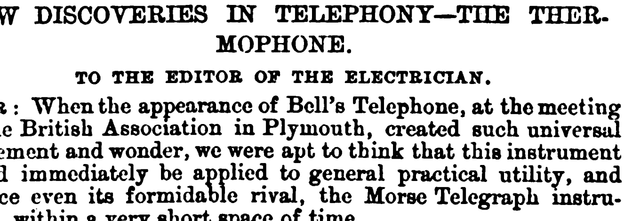


FIG. 1

The deficiency in intensity of the sound produced was considered to be due to magneto-action. For this reason, scientific men have thought it expedient to advise inventors to abandon the known principles, and, if possible, to open a new route of progress in telephony.

We have devoted a great amount of time and much effort to this end, and beg to submit here the result of our endeavours in experimental research. In looking for a new source of sound for the telephone, we directed our attention to *(a)* the sonorous vibrations produced by the expansion of bodies under the influence of heat, and *(b)* to the production of heat by means of the electric current.

Whenever a quantity current is sent through a circuit consisting of two stout copper wires, to whose extremities are attached the ends of a bad conductor, say a short piece of thin platinum wire, the latter immediately becomes red hot, and, if the current be powerful enough, it instantaneously fuses. It should be remembered that no appreciable amount of time is required for this action. Sulphide of copper is known to develope so much heat under these conditions as to form the prime element of an efficient electric fusee. Gas carbon and other bodies of low conductivity show the same results. The resistance thus interposed converts a portion of the electric current into heat. As bodies are known to expand when subjected to a higher temperature, the platinum wire, or gas carbon, or sulphide of copper, &c., will increase in length, width, and height, and thereby produce a condensation in air. (We would point out here that soft iron or steel under the influence of electro-magnetic induction only increase in one dimension.) When the above-named substance cools it contracts, and must cause in the surrounding air a rarefaction to a corresponding degree. When these impulses re-occur periodically in rapid and regular succession, they produce on the human ear the impression of sound.

While experimenting on this subject, we employed an electro-magnet, whose coil consisted of a tubular piece of inferior iron, the coil of copper wire (No. 26). We noticed, with interest, that, under the influence of powerful currents, produced by the battery of our "music telephone," the magnet in a short time became appreciably heated. Iron of inferior quality is very intolerant to electro-magnetism, and this resistance to induction produced the heat. We thought, then, to have discovered here a means of intensifying the effects above described by utilising as a source of heat not only the resistance of a bad conductor to the passage of the electric current, but also the resistance offered by iron

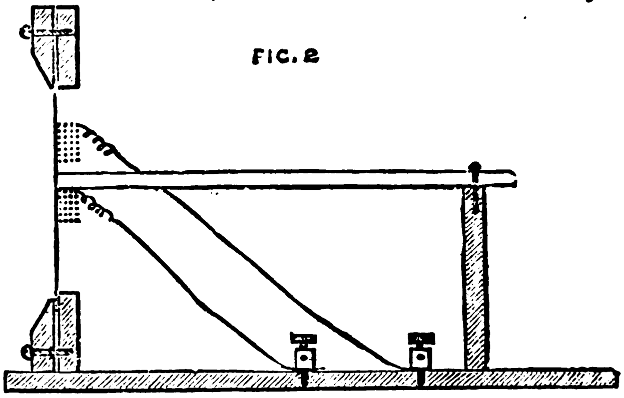


FIG. 2

or steel to electro-magnetic action, the energy inadequately termed "coercive force." Direct electro-magnetic action has been employed in our instruments to a limited extent only. The combined effects of these three kinds of impulses produce what, until now, was vaguely called "molecular vibration." The bad conductors we interpose in our instruments are small coils of very thin insulated wire of German silver, platinum, or copper. The sounds emitted by these coils are quite distinct, but very faint, and we intensified them by adding the effects of the resistance of coercive force to electro-magnetic induction, and also by producing these sounds on resonant surfaces or cavities. By these means we succeeded in constructing very efficient receivers without the use of magnets proper. One of these instruments is of the following construction (see illustration, Fig. 1):—

Three discs of thin charcoal iron, one ⅝in. diameter, the other two of 3in. diameter, are varnished on both sides and afterwards glued together, the smaller disc between the centres of the two larger ones. A very thin reel is thus formed, and on it is wound a coil of about five to ten yards only of silk-covered copper wire, No. 36.

This reel is then glued on the centre of a thin membrane stretched over one end of a brass tube 4in. long, 3½in. in diameter.

Another receiver is constructed as follows (see illustration Fig. 2):—A tube of tinned iron 6in. long, ⅛in. in diameter, is soldered in one spot only (not all round) to the centre of an ordinary Bell's telephone disc, moulded on a stand. A coil such as described above, or longer, is wound round the tube in close proximity to the disc. This disc and tube combined prove to be an excellent resonator. We found it as delicate to sonorous vibrations as the acoustic telephone with the string kept tight. With this receiver we hear the tune of a musical box and speech reproduced with great fidelity in quality as well as in pitch, and with considerable intensity. A tube of tinned iron, 3in. long and ⅛in. in diameter, wound with a small coil of insulated wire, will reproduce telephonic sounds.

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Fig. 3 represents a form of thermophone where the bad conductor interposed is a long and thin rod of gas carbon or plumbago. It rests on a spring support, and can be made to bear with different amounts of pressure on the centre of the disc by means of an adjusting screw. This instrument acts well as a receiver after the exact adjustment has been experimentally determined, an operation which sometimes involves much time and patience. It need hardly be mentioned here that the same instrument forms an efficient transmitter.

These instruments forcibly demonstrate that neither disc nor magnet are essential portions but only accessories of a telephone receiver, and their performance cannot leave any doubt as to the correctness of the theory we expound.

Nevertheless, we must expect adverse criticism on our explanation of the action of these instruments. The principal theoretic argument brought against us will be that a succession of changes of temperature so infinitely rapid as to produce sound by the expansion of the bodies acted upon is an impossibility. But exactly the same argument was used against the rapidity of electro-magnetic changes until the performance of Professor Bell's telephones vanquished the rash hypothesis.

I would refer those who entertain any doubts to experimental verification of these facts, and ask them to wind *one* yard only of insulated wire around an ordinary steel spool of a sewing machine, to include that miniature coil together with a strong battery in an electric circuit, and to make and break contact very rapidly. The results thus obtained will be a more convincing proof than any assertions I can make in writing.

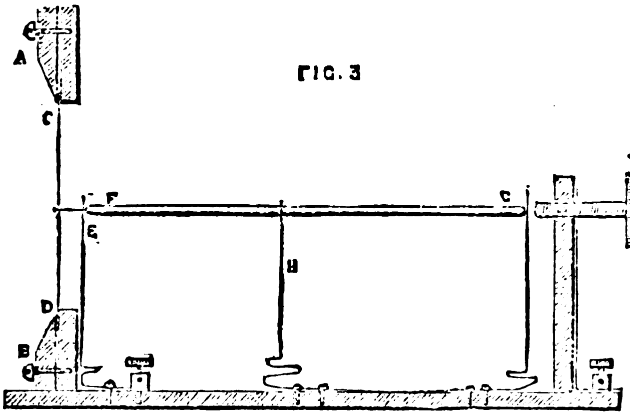

FIG. 3

While engaged in active research on these receivers, we heard reports on Mr. Blythe's and Mr. Hughes' microphone receivers; and it struck us then that the principle of action of these instruments was exactly the one we were experimenting upon. The carbon, as an inferior conductor, offers a considerable resistance to the passage of the electric current, its temperature is raised in degrees corresponding with the intensities of the currents sent, and it will expand by heat in degrees corresponding with the undulations of the current as produced or varied in the transmitter by sonorous vibrations of different amplitudes.

We were struck not to hear of any successful repetitions of Mr. Blythe's experiments. The principle of action evidently has not been understood, and experimenters, instead of using quantity currents, employed the usual microphone batteries, which are, of course, exceedingly weak, and whose currents only produce minimum effects of the nature described.

The principle we explained allows of a great many different applications. We have produced a variety of receivers; none are so perfect as we could wish, nor even so efficient as a good "Bell's telephone;" but, no doubt, inventors and other students in telephony will take up the work and experimentally develope it further. So far, we feel satisfied in having discovered the principle and experimentally established the possibility of reproducing sounds by thermo-action, through conversion of forces. A new route is thus opened to scientific research, and to progress in telephony.

THEODOR WIESENDANGER.

THE BRITISH ASSOCIATION.

LIGHTNING CONDUCTORS.

The following Paper was read at the recent meeting at Dublin by Mr. ANDERSON, F.C.S.:—

One hundred and twenty-six years have elapsed since Benjamin Franklin discovered, by means of his famous kite, that lightning could be drawn from the clouds, and its destructive qualities extinguished by very simple means; and one hundred and ten years are gone by since the first of Franklin's "lightning rods" was set up for protection over the dome of England's metropolitan cathedral. St. Paul's. Yet, so slow has been the "march of progress" in the application of one of the greatest scientific discoveries of modern times to the uses of daily life, that even now, after the lapse of more than a century, the employment of lightning conductors, simple as they are, and as inexpensive as simple, is far from being general, still less universal. At least one-half, and, perhaps, two-thirds, of all the public buildings, including the churches and chapels, of Great Britain and Ireland are without protection against lightning. As to private houses, it is safe to assert that not five out of every hundred have lightning conductors. It is well-known that the amount of property destroyed annually by lightning is very great, though it is naturally impossible to form any estimate of it. However, there are some facts as to the annual destruction of human life. According to the Thirty-ninth Report of the Registrar-General, issued in July, 1878, and former reports, the number of deaths from lightning in England and Wales was 182 from 1869 to 1876. In Prussia, where the registration of the causes of death is under the enforcement of strict legal enactments, and, in consequence, far more accurate than in England, there were 819 persons reported as killed by lightning in the eight years from 1869 to 1876. The population of Prussia is larger than that of England and Wales—25¾ millions against 24½ millions—but, on the other hand, thunderstorms are less frequent there than with us. Altogether, it will be rather under than over the mark to say that as many persons are killed by lightning in England as in Prussia, the loss of life amounting to over a hundred every year on the average. The terrible losses, both of property and human lives, still occasioned by lightning are the more lamentable as they are in nearly all cases the result of the grossest negligence. The negligence is threefold, namely—first, in not providing any lightning conductors at all; secondly, in not placing them in the right position, or in sufficient number to cover a given area; and, thirdly, in not having them regularly tested so as to ascertain their constant efficiency. Of course, the first-mentioned cause of neglect is by far the most important. It is one alike astounding and baffling all search for a reasonable explanation. Every year brings its regular thunderstorms, more or less in number, and most of them accompanied by fatalities. All see the terrible lightning flashing over their heads, all tremble before the approach of the awe-inspiring electric force, the mere touch of which brings instantaneous death, and yet but an excessively small number of persons make any efforts to protect themselves, their families, and houses against the electric fire from the clouds. Public buildings fare very little better than private houses. Even some of the first cathedrals of England, such as Peterborough, have no lightning conductors whatever, while others, supplied with them, are insufficiently protected, as apparent to any competent observer. A glaring case of absence of protection against lightning is to be found at Windsor Castle, the grandest of all the historic buildings of England, and the residence of our Sovereign. It may seem incredible, but I can vouch for it as an actual fact, ascertained by myself on a quite recent visit, that several portions of the noble pile, among them St. George's Chapel, home of the illustrious Order of the Garter, and the adjoining belfry tower, overhanging the main street of Windsor town, are entirely unprovided with lightning conductors. On other parts of the castle a few conductors are placed, but clearly not enough. It is needless to say that, speaking only of St. George's Chapel and the belfry tower, these splendid ancient structures, in their exposed situation, constantly touched by the storm-clouds that sweep up the valley of the Thames, are liable any moment to destruction, with irreparable loss to the nation. I now come to the third cause of neglect, which, though ranged as the last, is by no means the least. My argument is that lightning conductors ought to be at regular intervals, at least once a year, carefully inspected, and their efficiency tested by a galvanometer. The absolute neglect of this precaution, which is now prevailing, is, I believe, the cause of a vast number of casualties by lightning, inflicted upon buildings nominally protected by conductors. Exposed as they are to all the destructive influences of wind and weather, and the often still more pernicious assaults of ignorant workmen, masons, bricklayers, and others, who, while undertaking repairs, tear down ruthlessly, as a nuisance, the wonderful yet fragile string of metal which leads the electric flame on its path, it but too frequently happens that persons who have had the wisdom to erect lightning conductors over their houses, and believe themselves fully protected, are in reality far worse off than being without a conductor. But utter neglect of the conductor, when once it has been put in its place, is the commonest thing, and indeed the rule, as regards private dwellings; and, I fear, there is little difference in this respect as to most public buildings, churches, and chapels. In fact, it is the old case of a matter, however consequential, yet being utterly disregarded as "nobody's business." Other repairs to all sorts of public buildings are regularly executed; the walls are kept safe; painting and whitewash are renovated from time to time; the roof is preserved watertight; and the turret clock, if there is any, is thoughtfully looked after, oiled, cleaned, and repaired. But who is there that ever inspects the half-hidden little thing on which the safety of the whole fabric against the destructive effects of lightning depends? I made a great many inquiries on this highly important subject, and the more I did the more I was surprised at the profound negligence generally prevailing about it. Between three and four thousand pounds were spent in protecting the Houses of Parliament by lightning conductors at the time of their erection some twenty years ago. Since that time, as far as I can learn, after minute investigation, they have never been tested, and there is no guarantee whatever that a discharge of lightning may not at any time fall upon the Queen's throne, the Lord Chancellor's woolsack, or the Speaker's chair. As regards Windsor Castle, already referred to, the case is even worse. While parts of it are entirely unprotected, it is excessively doubtful whether the few conductors placed upon some of the eminences of the vast range of buildings are at all efficient, and not merely a "delusion and a snare." It is well known that the all important matter in respect to a lightning conductor and the principal element of its efficiency is the earth connection, that is, the immediate and complete dispersion of the electric force after it has made its way from the clouds through its metal path in the ground below. Moist earth is indispensable for the purpose, and I am very sceptical as to whether the few rods that stand over the Queen's private apartments at Windsor Castle and the culminating mass of brickwork, the Round Tower, actually have their root in moist earth. If not, it would be better certainly the things were taken away altogether, and the whole magnificent structure treated like St. George's Chapel and the Belfry Tower. A French writer pithily expresses the results that follow from a lightning conductor over a house not having a

proper "earth conductor," by saying it is lightning guided to the owner's iron bedstead. Having drawn attention to the chief causes of the numerous and fatal casualties caused every year by lightning, I have only to add a few words of advice as to how they might be prevented, or at least greatly diminished. First of all, I think it most desirable that public recommendation should be made, by local and other authorities, to place lightning conductors on all exposed or high-lying buildings, whether public or private, as well as on those standing near woods and on moist ground. It might be well worth the trifling expense to place simple conductors also against trees in parks, under which there are benches, or where persons are likely to gather during a thunderstorm, they forming a prolific source of fatal accidents. Above all, no church, chapel, school, prison, or other large public building, ought to be without one or more lightning conductors. There can be no excuse whatever for omitting this simple protective means against death and destruction, which may come at any moment, in the cases of edifices devoted to public or national uses. But, if it is necessary to greatly multiply lightning conductors, it is equally so that they should be planned and erected by competent persons, with scientific as well as practical knowledge of the work. There are a hundred circumstances which ought to be taken into account in selecting the best positions for conductors, especially on large buildings and those of irregular construction; and only great experience, as well as cognition of all that we know about the movements of the electric force, can accomplish it. Of first importance are the considerations of the general design of the building that is to be protected: the soil on which it stands, whether dry or moist; the presence of masses of metal in or near the roof of the walls, as in the case before mentioned; the position of the chimneys, and similar matters affecting the course of the electric discharge of the clouds. It would be quite impossible to lay down absolute rules on the subject; still, protection against lightning may be effected with the greatest certainty, under the guidance of well-known facts and observations which throw light upon the undeviating path of the mysterious electric force. But if everything possible has been accomplished towards the erection of the most perfect lightning conductor, there still remains something to be done. It is not only to construct a faultless conductor, but to maintain it always in good condition. This is a matter which, sadly neglected, and overlooked to a quite astounding degree, cannot be too much insisted upon. It ought to be universally known that a lightning conductor is worth nothing unless it is periodically tested. The testing should take place at regular intervals, perhaps best in the spring, before the advent of the summerly thunderstorms, and it should likewise be made whenever a building has been undergoing repairs which may have damaged the conductor. To show the importance of constantly testing even the best laid conductors, I can cite another instructive case where a house was apparently well protected. On the 19th of August, 1876, shortly before midnight, a heavy stroke of lightning fell upon the mansion of Mr. Evans, civil engineer, "Clayponds," near Kew-bridge, Middlesex. The electric force destroyed the top of a large chimney, knocking off part of the coping, not more than two or three feet from a lightning conductor, to which it then flew, making its way down to the earth, but not without causing the greatest disturbance all along its path—lifting up, among others, some heavy marble toilet tables in bedrooms some six feet distant on either side from the copper rope, which, under ordinary circumstances, would have carried the electric force noiselessly, as well as harmlessly, to the ground. The fact of this disturbance indicated at once the source of mischief. The lightning-conductor, good as it otherwise was, had no sufficient earth connection. It went into the earth, it is true, but into soil altogether dry, and, therefore, the conductor did not, and could not, act properly. It thus came to pass that, first of all, the lightning did not touch, as it would otherwise have done, the conductor directly, but sprang upon the coping of the neighbouring wall; and that, although it made its way down into the earth afterwards, it did so, as it were, with the greatest effort, which caused the lifting up of the marble tables and other disturbances. Nothing was wanting in this case for protection against lightning but regular testing, in default of which it can never be known whether a conductor is actually efficient at any time. A well-organised system of inspection of lightning conductors would be most inexpensive. The galvanometer used for the purpose has been latterly much improved in Germany, and small portable instruments, of the size of a diminutive carpet bag, are now made, which leave nothing to be desired in the shape both of effectiveness and durability. As the clock in churches and other public buildings is methodically inspected by the clockmaker, so ought every lightning-conductor to be as systematically examined by an electrician or other competent person. Already such a system of inspection and testing of conductors exists in Paris and several other French towns. Shall we say, once again, "They manage these things better in France!"

BINAURAL AUDITION.*

By Silvanus P. Thompson, D.Sc., B.A., Professor of Experimental Physics in University College, Bristol.

The author communicated to Section A of the British Association, at Plymouth, in 1877, the discovery of the two phenomena—firstly, the existence of an interference in the perception of sound; secondly, an apparent subjective localisation of simple sounds at the back of the head, when led to the two ears in such a manner that the two vibrations reached the ears in opposite phases. The present paper (Part II.) recapitulates the former experiments, and gives some further account of the phenomena, and of new methods of experimentation.

The existence of an interference in the perception of sounds was demonstrated by leading separately to the ears, with india-rubber pipes, the sounds of two tuning forks struck in separate apartments, and tuned so as to "beat" with one another; the beats being very marked in the resultant sensation, although the two sounds had had no opportunity of mingling externally, or of acting jointly on any portion of the air which conveyed the sounds. Tuners of forks usually tuned them, striking both, and holding one to each ear, and listened for beats. These experiments are not to be explained by the usual explanation given in text-books of acoustics.

The apparent localisation of sounds at the back of the head, when their vibrations reached the ears in opposite phases, is a subjective phenomenon of very singular interest. Its existence was first demonstrated by leading to the two ears the sound of two unison tuning forks, one of which was slightly loaded, to make its phase change slowly, relatively to the other. The "beats" are not "silences," as ordinarily observed when the difference of phase is complete; the sound is still going on, but seems to be taking place "within the cerebellum." The bulk of the present memoir is concerned with a further investigation of this phenomenon.

The telephone of Graham Bell has furnished an instrument peculiarly adapted for researches of this nature. Both the phenomena recapitulated above have been reobserved by many experimenters; amongst them by Sir William Thomson, and by Professor Graham Bell (see *Journal of Society of Arts*, November 30, 1877). One important advantage of the telephone as an instrument of research is that the phase of its vibrations can be inverted at will by simply reversing the connexions of the receiving instrument, so that the currents traverse the coil in a reversed direction. Many experimenters when using a pair of receiving telephones have noticed the apparent localisation of the sound at the back of the head, but few had noticed that this was the result of reversed action in the two instruments. When the two vibrating discs execute similar movements, both advancing or both receding at once, the sound is heard as usual in the ears; but if the action of one instrument be reversed, so that one disc advances while the other recedes, the sound apparently changes its place and is heard—at least at first—as if proceeding from the back of the head. Professor Hughes and others employ this fact to ascertain whether a pair of telephones are rightly adjusted or not.

The author's recent investigations were directed to inquiring how this apparent localisation is affected by the pitch, the phase, the intensity, and the "timbre," or quality of the two sounds; and whether combinational tones could be thus heard. The results arrived at are as follows:—This localisation of a subjective acoustic image is independent of the pitch of the sounds. Shrill tones and base tones are alike localised at the back of the head, either with the telephones or by the method of retarding one vibration by half a wave length by sending the sounds to the ears through india-rubber tubes of unequal lengths. One rather singular experiment is described as follows:—"I arranged a Hughes microphone with two cells of Fullers' battery and two Bell telephones, one of them having a commutator under my control. Placing the telephones to my ears, I requested my assistant to tap on the wooden support of the microphone. The result was deafening. I felt as if simultaneous blows had been given to the tympana of my ears. But on reversing the current through one telephone I experienced a sensation only to be described as if some one were tapping with a hammer on the back of the skull from the inside."

When the difference of phase is partial, the effect is mixed, the sensation being localised partly in the ears, partly at the back of the head.

If the difference of phase be complete, and the intensities unequal, the acoustic "image," instead of being at the middle of the back of the head, is nearer to that ear in which the sound is louder.

It is possible to discern a difference between two compound tones which differ only in phase, but not in the pitch, or intensity of their component partial tones. For when two such compound tones are separately brought to the ears, so that the vibrations of any particular partial tone present reach the ears in opposite phases, that particular partial tone is singled out and localised at the back of the head. Thus, the use of the two ears enables us to discern differences of phase, which contradicts the statements of Helmholtz and Sedley Taylor.

As to the cause of this singular localisation, the author hesitated to advance a theory until the physiological and anatomical conditions involved were more definitely ascertained. The phenomenon of interference in the perception of sounds could not be explained by a supposition of a blending of the sensations, similar to that which takes place for sight in binocular vision, for, unlike the optic nerves, the auditory nerves, or *portio mollis*, did not join or mingle after diverging from their point of origin in the brain.

Next, the author had ascertained by repeated experiment that in binaural audition the differential tone corresponding to a simple interval was wanting. Thus, if we strike two tuning forks e'(=320 and g' (=384), together giving the interval of a minor third, there will be heard also a very low note corresponding to the difference between 320 and 384 vibrations, or 64 vibrations per second, provided the two sounds really mix before being heard. But, if these two tones are led separately by pipes to the two ears no such tone is to be heard. It was remarked in the paper of the preceding year that in binaural audition dissonances are excessively disagreeable, and the ordinary consonant intervals harsh. It was probable that this was connected with the absence of the differential tones.

* Abstract of paper read before Section D of the British Association, Dublin Meeting.

TELEGRAPH SHARE LIST.

Companies.	Closing Prices Sept. 18.	Business Done Week Ending Sept. 18. Highest.	Lowest.
Anglo-American	60¾, 61¼	61¼	60¾
Do. Preferred	90¼, ¾	90¾	90¼
Do. Deferred	34¼, ¾	34¾	34¼
Brazilian	6 13-16, 15-16	6 15-16	6¾
Cuba	9½, 10	9¾	—
Do. Ten per Cent. Preference	15¾, 16¼	16	—
Direct Spanish	1¾, 2¼	—	—
Do. Ten per Cent. Preference	9¾, 10¼	10¼	—
Direct United States	13, ½	13½	13⅜
Eastern	7⅜, ⅝	7½	7⅜
Do. Six per Cent. Debenture	106, 108	—	—
Do. Five per Cent. do.	99, 101	—	—
Do. Six per Cent. Preference	11 9-16, 11-16	11⅝	11½
Eastern Extension	7 5-16, 7-16	7 7-16	7¼
Do. Six per Cent. Debenture	106, 109	107½	107¼
German Union	8, 8½	—	—
Globe Telegraph and Trust	5¼, ½	5 7-16	5¼
Do. Six per Cent. Preference	10 15-16, 11 1-16	11	10¾
Great Northern	8¼, ½	8½	8¼
Indo-European	20¾, 21¼	—	—
Mediterranean Extension	3, ½	—	—
Do. Eight per Cent. Preference	9½, 10	—	—
Reuter's	10, 11	—	—
Submarine	216, 221	—	—
West India and Panama	2 1-16, 3-16	2⅛	2 1-16
Do. Six per Cent. Preference	8½, ¾	—	—
Western and Brazilian	3¾, 4¼	—	—
West. Union 7 p. Cent. 1st Mortgage	114, 118	—	—
Do. Six per Cent. Sterling	99, 101	—	—

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NOTES.

Imperfections of the Telephone.—Serpieri and Capanera have studied the sounds which are only imperfectly transmitted by the telephone, and find a frequent confusion of the following sounds:—*E, a; tr, cr, dr, pr, fr; n, m; s, f; et, el; eb, eu; d, t; ic, ip; dra, tra, gra; te, chi; at, ai; i, u; l, r; o, e; v, b.*—*Ding, Polyt. Jour.*

Effect of Flame on an Electric Spark.—Have any recent experiments been made in this direction? We know, for example, that M. Mische inserted a jet from a glass tube drawn out to a point, with a flame an inch long and one-eighth of an inch in diameter, between the terminals of a Holtz machine, and increased by this means the length of the spark from ten inches to more than twelve.

Telegraphs.—Owing to a typhoon, the Great Northern Telegraph Company's cables between Nagasaki and Shanghai, and between Shanghai and Amoy, are interrupted. The repairing steamer is on the spot, and a speedy restoration is expected. Meanwhile messages for Hong Kong and Amoy cannot be accepted, and messages for Shanghai will be forwarded from Nagasaki by steamer. The company's lines to all Japanese stations work well.

Proposed Introduction of the Electric Light into the North British Dyeworks, Perth.—Several experiments were made with the electric light last week in the extensive dyeworks of Messrs. J. Pullar and Sons, Perth, for the purpose of introducing the same into some of the rooms instead of the ordinary gaslight. The experiments were very successful, and we believe the electric light will soon be introduced into the works, which are the most extensive in the kingdom.

Ladd's Electro-Magnetic Motor.—According to M. Deprez, this machine gives very good results, and has been too much lost sight of. A curious peculiarity presented by this machine is that, if the commutator be placed in the position which, theoretically, should render all movement impossible, the machine will, nevertheless, rotate indifferently in either direction. The velocity is even much more considerable than that obtained with the commutator in a rational position.

Terrestrial Influence on Polarisation of Light.—In the course of his researches on rotary magnetic polarisation, Henri Becquerel has been led to the direct estimate of the action of terrestrial magnetism upon different bodies. In the course of these experiments he has found that if a tube, containing bisulphide of carbon, is placed between a polariser and an analyser, in the plane of the magnetic meridian, there is an angular difference of 6·5′ between the two positions of the plane of polarisation when looking towards the south or towards the north. This difference he attributes to terrestrial action.—*Comptes Rendus.*

Winding Electro-magnets.—A fact likely to be very useful in making electro-magnets has just been communicated to the French Academy of Sciences by M. Jamin, on behalf of M. E. Bisson. It is found by the latter that if, in winding the wire on the core of electro-magnets, the wires, after completing a layer, be led back *straight* to the point of departure again to begin the next layer, instead of winding the next layer backwards so as to fill up the bobbin by layers wound in reciprocal directions, as is usually done at present, a gain of one-third in magnetic power will be obtained, every other condition being the same. This gain it manifested either in sliding, pulling, or attraction at a distance.

"Polarisation" of Electrodes.—M. Lippmann has presented to the French Physical Society the results of his experiments on the polarisation of electrodes. His researches have led him to formulate the following law:—*A metal can be completely depolarised only in* (solutions of) *its own salts.* A novel method of chemical analysis may result from this law; we may be sure, for instance, that copper is present in a solution if a copper wire cannot become polarised in it by the passage of a current. M. Lippmann calculates that the presence of even 1-5,000th of copper in a solution containing other salts may be detected by this means, provided always that copper has itself no action upon the other salts.

Is Electricity Light?—This rather startling statement was the heading of a letter recently appearing in a contemporary, but still we doubt if the fact is proved. Scepticism is natural, even when the experiments of Professors Ayrton and Perry give equivalent velocities to Light and Electricity. We may be on the high road to discover what electricity is, and give such proofs as will generally be accepted by scientific men, but as yet eminent men are undecided as to the answer of the question, What is Electricity? M. Rotti and others have attempted to attribute it to ether currents, and, if we are not mistaken, Mr. Preston not only imagines one great ether system, but he would have two, or, if required by the exigencies of his theories, three or thirty. M. Edlund differs, to a certain extent, from MM. Rotti and Herwig, but he theorises that electricity is identical with the luminiferous ether.

Explosion of Powder by Lightning.—The recent explosion of two powder magazines by lightning, one attended with considerable loss of life, emphasises the need of great care in the placing of such structures and in providing them with proper lightning conductors. The first explosion occurred in England, August 8, the magazine belonging to the Victoria Colliery, at Bruntcliffe, and containing one ton of powder. Several persons within range of the explosion were severely injured. The magazine was situated in the middle of a field, 400 yards from the colliery. The shock was terrific, and but for the incessant rain which preceded the explosion, and had the effect of stopping all traffic in the vicinity, many lives, it is thought, would have been lost. The second explosion occurred near Pottsville, Pa., August 17, the magazine containing 1,100 kegs or 25,000lbs. of powder. There was a picnic party assembled in the neighbouring wood, half a mile distant across a valley. Three were killed instantly and several injured, some fatally. Many houses in the neighbourhood were wrecked.

Regulator for Electro-Magnetic Motors.—M. Marcel Deprez exhibited before the Physical Society the working of several electro-magnetic machines, the motion of which was rendered absolutely regular by means of a special regulator. This is composed of a simple spring attached to the circumference of the fly-wheel, or of some other wheel forming part of the machine, and terminated by a small mass which presses against the axis. The current which works the machine traverses the spring. So long as the velocity is within certain limits, the current passes; but, when these limits are exceeded, the increase of centrifugal force causes the mass which terminates the spring to fly from the arbor, and the circuit is broken, the result of which is immediately to reduce the speed to that which allows of the mass to make contact with the arbor, and thus to close the circuit. Comparing different electro-magnetic motors with each other, M. M. Deprez arrives, by considerations of a different order, at a result which has already been indicated by M. Muscart, viz.,

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that the most advantageous machines should have very large permanent magnets and small coils.

TELEPHONIC.—The form of telephone adopted by M. Righi has for the receiving instrument a Bell telephone, with a membrane of parchment paper, in the centre of which is a small disc of iron. The magnet is much larger than that usually employed. The transmitter is formed by a plate or a membrane—which may be of almost any kind, even a piece of board—which is supported in the centre by a metal rod, which rests upon a conducting powder contained in a metallic capsule. The rod and the powder are traversed by a current from three Bunsen cells, which current passes to the receiver. The variation of the pressure of the rod upon the powder affects the resistance opposed to the current, and thus the mode of action is in theory the same as in the carbon telephone. The conducting powder used is a mixture of plumbago and chemically precipitated silver. In some experiments made by M. Righi with this telephone, spoken words, the sound of a flute, and that of a *cornet à pistons*, were transmitted from a distant room, and were readily heard by every person in the hall where these experiments were shown. When the transmission is to be effected through a great distance, it is advantageous, in the case of this telephone, to close completely, at each station, the current or the transmitter and receiver, including in this current the primary wire of a Ruhmkorff's coil. The secondary wire of this instrument is then connected to the line and to earth, the line thus being completely insulated from the telephonic instrument.

FREEING A MAGNETIC BAR FROM THE INFLUENCE OF THE EARTH'S MAGNETISM.—Dr. Joules' method may be well known to most readers, while that of Professor Trowbridge may not be so well known, and, therefore, we give it a place among our "Notes." An ordinary tangent galvanometer is so constructed that the coil is free to turn about a vertical axis, and also about a horizontal one. The coil is first placed in a plane, perpendicular to the magnetic meridian; it is then turned about its horizontal axis until the component of the strength of the current acting in the horizontal plane shall be just equal and opposite to the horizontal component of the earth's magnetism. A figure can be easily constructed to assist in the illustration of this system. Draw rectangular co-ordinates a; draw $a\ b$ to represent strength S of current passing through galvanometer coils at the angle θ which the plane of the coil makes with a vertical plane. We have $S \cos. \theta = \mu$, in which μ is the counter-balanced force of the earth's magnetism. Under these conditions, the magnetic needle is in a state of unstable equilibrium, and, if placed perpendicularly to the magnetic meridian, will vibrate through small arcs free from the action of the earth, and subject only to the attraction in the field of force in which it may be placed. A bar of soft iron placed in the vertical plane which passes through the suspension of the needle perpendicular to the magnetic meridian at a suitable distance from one of the poles of the needle, serves to bring it back to zero, just as the controlling magnet serves a similar purpose in Thomson's reflecting galvanometer.

M. AILHAUD'S RECORDER FOR CABLE WORK.—*Annales Télégraphiques* for July-August gives a short but interesting account of this instrument. It points out that the currents employed upon submarine lines are very feeble, and that the electro-magnetic force of the receiver is not sufficient to overcome the inertia of ordinary recording instruments. Sir William Thomson has overcome the difficulty in his Syphon Recorder, and we may say that submarine telegraphy is a fact due to a great extent to the scientific ability of this renowned electrician. M. Ailhaud has devised a little apparatus which has for its object the recording of submarine signals. Two electro-magnets are opposed horizontally to each other, while between the poles are placed two small bar magnets. The latter are connected vertically by an aluminium thread, which is carried above and below the magnets, the top being fastened to the silk which suspends the system; the bottom ends in an iron point plunged into mercury, held by an iron cup. Midway between the two bar magnets, and joined to the vertical strip of aluminium, is a very light aluminium finger, which moves under the influence of the currents sent. The method of recording is ingenious. Chemically-prepared paper passes over a metallic cylinder. The end of the aluminium finger is just above the paper. The metallic cylinder and the iron cup containing the mercury are connected through an induction coil to a battery. Thus, the finger and the cylinder are charged with electricity of opposite sign, and a spark passes, which, acting upon the above-mentioned paper, leaves the record. So long as the finger remains stationary the recorded line is straight, but when a signal actuates the finger and causes motion the line becomes wavy, similar to that of the syphon recorder. The motion of the finger is restricted by two stops, and a directing magnet is used to adjust the system.

M. A. RICCO ON PROFESSOR PALMIERI'S INSTRUMENTS.—Professor Palmieri's diagometer is an instrument designed to test the quality of oils, and is based upon the principle that olive oil is a poorer conductor of electricity than any other oil in common use, and that mixtures and oils made from seeds are the better the more resistance they offer to the passage of electricity. The oil is poured into a glass vessel, in which dip two brass rods. The points of these rods are kept at the same distance apart during the experiments, and also at the same distance below the surface. By means of two arms, the rods are connected with two insulated balls, the former of which communicates with a Zamboni's dry pile, and the latter with a Palmieri's electrometer. In Palmieri's electrometer the electricity, which we will suppose to be positive, passes into a little fined brass cup furnished with brass arms. In the cylindrical cavity of this cup a disc of aluminum is suspended by means of two single threads of silk diverging from a brass hook. The disc has likewise two fine arms of the same metal. Electricity, contrary to that in the cup, is induced in the disc, and electricity of the same kind is repelled in the arms, in consequence of which the arms or indices of aluminum, situated opposite to those of brass, swing over a graduated circle. The arc described by the index at the first impulse is commonly double that obtained finally when the apparatus is in perfect order. If the final arc is smaller, it indicates that there is some loss of electricity in the apparatus that must be taken into account. This fact gives a peculiar value to Palmieri's electrometer. If the oil poured into the vessel is olive oil, the aluminum index takes several minutes to swing through a few degrees; but, if the oil is made from seeds, the index swings through a considerable range in a few seconds. To test the value of oils it is only necessary to compare them at a constant temperature with a sample of pure olive oil, and to note the time required for the index to pass over a given arc in every case. Palmieri's diagometer may also be employed to detect the presence of cotton in silk fabrics. A strip 0·25 metre long and 0·02 wide is well dried and fastened to the rods. If it is pure silk, the electricity coming from the globe will scarcely move the index; but, if it contains cotton, the index will be quickly repelled, and will swing through several degrees.

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ELECTRIC ILLUMINATION.

II.—Production and Regulation of the Light.

Whenever two conductors, connected with the terminals of a powerful battery or magneto-electric machine, are brought into contact, and then slightly separated, the current continues to pass across the intervening space, giving rise to a brilliant light. The colour and intensity of the light depend on the nature of the substances between which it is produced. It is green with copper or silver, white with zinc or carbon. The amount of light produced from carbon far exceeds that from any other substance, and the infusibility of this body at the enormous temperature of the voltaic arc indicates it as the only material which can be practically employed. The purity and state of aggregation of the carbon is a matter of the greatest importance, and to this special attention has been directed. The original experiments of Davy were made with wood charcoal, which, besides being very impure, is so light and porous that it burns away rapidly, and is, in fact, quite unfitted for practical use. Foucault's idea, to employ the hard coke found deposited on the interior of gas retorts, which has been some time in use, was a great step in advance, and, for a long time, rods sawn out of this material were exclusively used; indeed, they are much used at the present day. This form of carbon, produced by the decomposition of the coal gas as it passes along the highly-heated walls of the retort, is extremely hard and compact, and fairly pure, but it is a little irregular in structure, and contains here and there portions of the fixed mineral constituents of the coal accidentally entangled in it. When the pieces have not been very carefully selected, the light produced is somewhat irregular, and the rods themselves are apt to splinter. In order to obtain a product of a similar nature, but of greater purity and uniformity, Jacquelain endeavoured to imitate intentionally that which happens accidently in the gas retorts. He effected the decomposition of hydrocarbons by causing their vapours to traverse intensely heated tubes, upon the walls of which a very pure and hard coke was deposited. The product thus obtained, although in every way satisfactory, was too costly for general use. The best carbon rods now manufactured for the production of the electric light are made by Gaudoin. This inventor prepares a perfectly pure carbon by calcining resin, pitch, or other suitable material, in crucibles. The tolerably compact carbon obtained in this way is reduced to fine powder, and then agglomerated, either alone, or with a little lamp black, or pitch. The mixture is submitted to the action of a powerful hydraulic press, and forced out through a small circular orifice. The apparatus used is somewhat similar to that employed for the manufacture of the loose leads for pencils, and the moulded rods of carbon are hardly to be distinguished from those made of plumbago. The Gaudoin rods give a light in every way satisfactory, free from irregularities, and of quite double the intensity of that obtained by the use of rods sawn out of gas retort carbon.

The great difficulty which the earlier experimenters with the electric light encountered was the proper adjustment of the distance of the carbon rods between which the light was produced. The limits within which a steady light can be obtained are extremely narrow, the least approach or withdrawal of the points causing a very considerable variation in the amount of light. As the action proceeds both pieces of carbon are gradually consumed, the positive pole burning about twice as fast as the negative, and, as this causes the ends of the rods to be constantly separating, some means must be found to bring them together as required. As the rate at which the carbons burn depends on their compactness, size, strength of the current, draughts of air, and many other circumstances, it is evident that no clockwork arrangement would keep them at a uniform distance; and to regulate them by hand would be, for practical purposes, out of the question. In order to meet the difficulty, Wright, of London, in 1845, proposed to cause two discs of carbon to revolve at a set distance from one another, by which he hoped to maintain a constant light; and this idea has since been developed and improved, the discs being placed at right angles, and brought nearer, when required, by the action of an electro-magnet.

In 1846, Staite and Edwards patented a very simple lamp. This arrangement consisted of two carbon rods inclined at an angle, and kept in their position by tubes through which they could slide. Their lower ends rested, close to each other, on a block of some very refractory substance. As the points burned away the rods descended by their own weight. Their ends, between which the light was produced, would always occupy the same position on the block, and it was hoped that a constant and steady light would be produced. This proposition never led to anything in practice, for, apart from the great shadow thrown by the block, there is no known substance capable of resisting the tremendous heat of the voltaic arc.

To Foucault is due the credit of making the electric light its own regulator. The principle upon which this is founded is very simple. When an electric current is caused to traverse an insulated wire, wound round a piece of soft iron, the soft iron is converted into a magnet. If the current, in any part of its course, encounters resistance, the power of the magnet diminishes. If the resistance is removed, the magnet at once recovers its strength. The greater the distance which separates the carbon points between which the light is produced the greater is the resistance offered to the passage of the current. If, therefore, an electro-magnet is included in the circuit, its attractive power will increase or diminish according to the distance separating the two carbons. Foucault, aided by Duboscq, an eminent instrument maker of Paris, constructed a lamp the carbons of which were caused to approach by clockwork. This clockwork was controlled by a moveable armature, which, on the one side, was attracted by an electro-magnet included in the circuit, and, on the other side, was subject to the action of a spring the power of which could be varied at pleasure. The apparatus was so arranged that, when the distance between the carbons became greater than the conditions of a good light required, the spring overcame the power of the magnet and set in motion the clockwork by which the carbons were caused to approach. As soon as they were sufficiently near, the magnet regained its power and, overcoming the spring, stopped the clockwork. An improved apparatus was afterwards contrived in which the carbons were either brought together or separated as required by means of two trains of wheels acting in opposite directions. These were set in motion according to the strength of the magnet. If the magnet was too strong, and consequently the carbons too near, the clockwork which separated the points began to act. If the magnet was too weak, and consequently the carbons too far apart, the other train of wheels was put in motion to bring them together. This ingenious apparatus is largely used in lecture rooms and for magic lanterns, but it is rather slow in its action, and does not instantaneously correct any little variations that may occur in the light.

Many other regulators have been contrived from time to time in the construction of which more or less ingenuity has been displayed by their inventors; but that of Serrin, although devised some twelve years ago, still remains the most perfect apparatus of this kind. Serrin dispenses with clockwork to cause his carbons to approach. In his apparatus the carbon holders run together of themselves. The upper one, which is far the heavier, acts by means of a rack upon a toothed wheel, on the axis of which is a drum connected by means of a chain with the lower carbon-holder in such a way that it ascends as the upper one descends. The upper carbon, which is always positive, moves twice as fast as the lower one. As this is about the proportion in which they are consumed, the light always retains the same position in space. The characteristic feature of Serrin's lamp is that the lower carbon is free to move within certain limits, and so counteract any little inequalities of the light, without putting into action the mechanism which allows the upper carbon to descend. The chain connected with the lower carbon-holder passes over a pulley fixed on a small hinged frame, which has a slight up and down motion. The arrangement is such that, on the one hand, without interfering with the movements of the frame, the descent of the upper carbon pulling on the chain causes the lower carbon to ascend, while, on the other hand, when the upper carbon is fixed, and, consequently, the chain motionless, the frame is free to move up and down, carrying with it the pulley over which the chain passes, and, consequently, the lower carbon-holder attached to it. This frame is suspended by a spring the tension of which can be varied at will, and to the lower part is fixed a piece of soft iron, which forms the armature of the electro-magnet, as in Foucault and Duboscq's arrangement. In addition to the spring and armature, the frame also carries a detent, which, when the frame rises to a certain point, and only then, liberates the train of wheels, which allows the upper carbon to descend and draw up the lower one.

The least variation in the current causes a variation in the power of the magnet, and, as the spring or the magnet get the upper hand, the frame carrying the lower carbon rises or falls, instantly correcting the least irregularity. If the rising motion of the frame, brought about in this way, exceeds a certain point, the detent releases the mechanism, and the points approach. Directly they are near enough, the magnet acts on the frame, which descends, stops the mechanism, and then continues its small oscillations with every little variation of the current. Even with the irregular currents of the battery, and the inequalities of the rods sawn out of gas carbon, the performance of this lamp is in the highest degree satisfactory, but, with the steady currents of the magneto-electric machine, and the uniform carbon rods made by Gaudoin, the light produced is as steady as that of a moderator oil lamp.

There is another regulator, invented by Von Alteneck, and

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manufactured by Messrs. Siemens. This lamp, which is largely used in Germany, and gives excellent results, is simple in construction, and may be used either with continuous or alternating currents. It is rather difficult to describe the construction clearly without the aid of a drawing, and it is not our purpose to go into the details of every contrivance. The description of Foucault's and of Serrin's lamps will serve to illustrate the general principles upon which automatic regulators are constructed.

Quite recently, Jablochkoff, a Russian engineer, has succeeded in getting rid of the regulator with all its complicated contrivances. Instead of causing the carbons to approach when needful, he makes the distance invariable from first to last. This he accomplishes by arranging the carbon rods parallel to each other, at the distance most favourable for the production of the light. The intervening space is filled up with plaster of Paris, or other suitable non-conducting medium. The current is established by means of a small piece of carbon connecting the two extremities of the carbon rods. This is almost instantly burnt away, and the current then passes from one rod to the other, melting and dissipating the edge of the non-conducting substance between them. As the rods burn down the non-conducting substance disappears too, both going together, like the wick and the wax of a candle. We have already stated that the positive rod burns away twice as fast as the negative rod. From this it is evident that, in the absence of some means of dealing with the difficulty, one side of the Jablochkoff candle would burn twice as fast as the other. An attempt was made to meet the case by making one of the rods twice as big as the other, but this expedient met with only partial success. It was found practically impossible to compensate the difference accurately in this way.

When speaking of magneto-electric machines, we pointed out that, up to the time of the Gramme machine, the induced currents were produced alternately in opposite directions, and that, in order to obtain a continuous current, it was necessary to rearrange them by means of a commutator.

Long before the time of Jablochkoff—indeed, shortly after the invention of the machine of the Alliance Company—it was known that the electric light could be produced directly by alternating currents without the necessity of converting them into a continuous current. That this should be so is rather curious, and somewhat opposed to our notions of dynamic electricity. This kind of electricity is unable to spring over any appreciable space. When, however, the conductors have been brought into contact and then separated, a condition of things appears to be set up in the intervening space which allows the current to leap over the gulf it was previously unable to bridge. What this necessary condition is, whether intense heat, vapour of carbon, or a cloud of finely divided particles of carbon, is not known. It is certain that, if the circuit is broken in any part, the voltaic arc at once disappears, and with it the conditions which enabled it to pass; for, on restoring the circuit, the arc does not reappear until absolute contact is again made, as at first. Strangely enough, these are just the conditions under which the light is produced when alternating currents are employed. The electricity first passes in one direction, producing the arc, the supply of electricity is then cut off, and a current produced in the opposite direction, but this current succeeds in leaping the space, and is then succeeded by a third in the same direction as the first. After what has been said, how is it that these insolated currents pass one after the other? It must be borne in mind that the interval in time between any two of the successive currents is very small. In the Alliance machines the direction of the currents is changed a hundred times in a second; in Gramme's machine, for alternating current, sixty times a second. We are driven to suppose that the necessary condition for the passage of the electricity is not absolutely annihilated the moment the current ceases to pass, but endures for an appreciable time, say the twentieth part of a second, and, if another current presents itself, after a sufficiently short interval, it will pass notwithstanding the interruption. With the continuous current the light is continuous, but with the alternating currents it is not. It then consists, in fact, of a series of sparks in opposite directions, which succeed each other so rapidly that to the eye the light appears to be unbroken. In the case of a light produced by alternating currents, each point is alternately positive and negative, and the consumption of the carbon is exactly equal. In the Jablochkoff candle, where the equal consumption of the carbons is an essential condition, nothing but alternating currents can be used The Jablochkoff candle burns very steadily and well. The arrangement is simplicity itself; there is no clockwork to get out of order, there is nothing but two thin rods of carbon separated by a little plaster of Paris. The whole arrangement is easy to construct, and is, or rather might be, exceedingly cheap.

Jablochkoff also claims to have accomplished the division of the electric light, and on this head it will be well to say a few words. The electric light is, as all the world knows, exceedingly powerful, light frequently equivalent to 500 or 1,000 gas lamps being concentrated into a space not much larger than a pea. Everything in the neighbourhood is illuminated in the most dazzling manner; but, as light diminishes as the square of the distance, more distant objects become plunged in comparative darkness. It is as if all the gas lamps in a long street were collected together at one point; that point would be lighted brilliantly, the rest of the street would be in darkness. Obviously, a great advantage would be gained if, instead of using one lamp for the illumination of any space, the current could be passed through a dozen lamps distributed at various points, each giving one-twelfth of the light afforded by the one lamp. All attempts to do this have resulted in failure. It was not that the current could not be passed through more than one lamp, but when so passed it was found practically impossible to regulate it. We have already explained that an electro-magnet varies in power according to the resistance in the circuit, and upon this is based the construction of the automatic regulator. But what is true of one electro-magnet is equally true of any number in the same circuit. Suppose three regulators placed in the same circuit. All are burning well, but one is burning the carbons rather faster than the others. In this one they will soon be further apart than in the other two, and a greater resistance will be offered to the current. That lamp will, of course, begin to regulate itself and bring the carbons nearer, but, all the electro-magnets in the circuit being equally affected, the other two lamps will also bring their carbons nearer together when, in fact, this was not required, so that then they will be brought too near and the whole system thrown out of gear. As the whole current is affected by the performance of any one lamp in the circuit, it is found that each lamp must have its own battery, or electro-magnetic machine, as the case may be; and more than one lamp cannot be used. In effect, the electric light was indivisible.

In the case of the Jablochkoff candle the conditions are altogether different. There are no electro-magnets. The distance of the carbons is invariable, and the special difficulties presented by the regulators disappear. That Jablochkoff has succeeded in effecting the divisibility of the electric light, that is, in obtaining several lights from the same circuit, is certain, but what the practical value of this achievement is becomes another question. In practice, he finds it is not safe to go beyond four lights in one circuit. He is obliged to employ alternating currents. Now, alternating currents, with the same expenditure of horse-power in the steam-engine, give only half the amount of light obtained from the continuous currents. Starting from the steam-engine, four-horse power is sufficient to drive two continuous current machines, each working a regulator, and producing in each lamp a light equal to four hundred carcel oil lamps. The same amount of force is required to drive an alternating current machine, working in one circuit four Jablochkoff candles, each producing a light equal to one hundred carcel lamps. The electric light is divided, it is true, but half the light has disappeared in the process. Have the regulators or the candles the best of it? Is it better to have eight hundred carcel lamps divided over two points, or four hundred divided over four points? That depends on circumstances. In any case, the gain by the subdivision is not very great. How far the recent great improvements in this mode of illumination have brought it nearer the domain of practice, together with its cost, and the special difficulties that remain to be overcome, we must reserve for another occasion.

ON TELEPHONY.

By W. Siemens.*

[CONCLUDED FROM P. 213.]

Further, secondary electrostatic induction, increasing as the squares of the length of the conducting-line, will soon, as the overland lines become longer, put a limit to the employment of the telephone, even when the telephone-wires only are fixed to the same posts.

The circumstances are much more favourable in this respect for the telephone when underground or submarine lines are employed. Before I had ascertained that the intensity of the currents which yet are capable of exciting the telephone to the production of clearly intelligible speech-sounds is so extremely slight, I doubted the practicability of employing subterranean wires for great distances, on account of the great weakening which the current-waves called forth by rapidly alternating electromotive forces in the conducting wires would undergo with the length of the conduction. The experiments,

* Translated from the *Monatsbericht der königlich preussischen Akademie der Wissenschaften zu Berlin.*

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however, which Postmaster-General Dr. Stephan (to whom the German Empire owes the reintroduction of the underground wires that had for a quarter of a century almost fallen into oblivion) caused to be made with Bell telephones, gave the surprising result that with them people can speak with perfect distinctness and quite intelligibly at distances of about sixty kilometres. Hence, it is very probable that, with telephones of more powerful action, adequate intelligibility will be attained at twice or even three times that distance. This, at all events, may be the extreme distance at which telephonic correspondence is generally practicable.

Unfortunately, even in underground conducting wires disturbances by return currents from the earth, as well as by electrodynamic and electrostatic induction, are not excluded. The former could be pretty completely got rid of, as in lines above ground, by the employment of entirely metallic conduction circuits, with the exclusion of the earth as return conductor. The same holds good in the case of disturbances produced by induction, if the two insulated conductors forming a telephone-circuit are united into a separate cable encased with iron wires. If, on the contrary, as is usually done for the sake of saving expense, a greater number of insulated conductors are combined in one cable, voltaic as well as static induction makes its appearance in augmented measure on account of the slightness of the distance between them, and act very disturbingly on the telephonic correspondence. This secondary electrostatic induction occurs perturbingly even in long cables for telegraphic correspondence, with which very sensitive apparatus must be employed. Hence, I have proposed for avoiding it, to provide the individual conductors which are combined in a cable containing several wires with a conducting metallic sheath in conducting connexion with the outer iron spinning or with the earth. Even encasing the insulated individual conductors with a thin layer of tin foil gets rid of secondary electrostatic induction completely. Any one can easily convince himself of this by experiment if he places one upon the other two mica or thin gutta-percha plates, each lined on both sides with tin foil. If the inner linings be insulated and the charge between the outer ones be tested by the deflection of a galvanometer, by connecting the free pole of a battery led away to earth with one of the outside sheets of tin foil, while the second is connected through the galvanometer-wire with the earth, or, in a similar manner, by aid of the commutator, as great a charge is obtained as if the sheets in the middle were absent. But, if the latter are connected with the earth, no trace is obtained of a secondary charge in the tin foil connected with the galvanometer.

We get the same negative result when the individual insulated conductors of a cable consisting of several such have been tightly wrapped round with tin foil or strips of thin plate of any metal. The metallic conductive casing, though very thin, completely prevents any secondary electrostatic induction or charge of one conductor by the charge of another. On the other hand, however, the electrodynamic induction, exerted by the wires upon one another is not thereby removed, as Foucault asserted.*

This can easily be convincingly shown by a simple experiment. If two wires, insulated with gutta percha or caoutchouc, be wound together upon a roller, powerful charge as well as voltaic-induction currents are to be observed in one of the wires when a galvanic series is alternately closed and opened by the other. If the roller be now placed in a vessel, and this be little by little filled with water, the charge-currents in the former wire diminish, and cease altogether when the water quite fills up the intervals between the wires, whereas the electrodynamically induced currents become even more intense.

For telegraph-conductions these electrodynamically induced currents are, as we have already remarked, of no consequence, since they do not increase with the length of the conduction; but the telephone, being so extremely sensitive, is still excited by them if the inducing currents are not extraordinarily feeble. It will therefore be necessary to lay down special cables for telephones, just as special posts are needed for them when the wires are carried above ground.

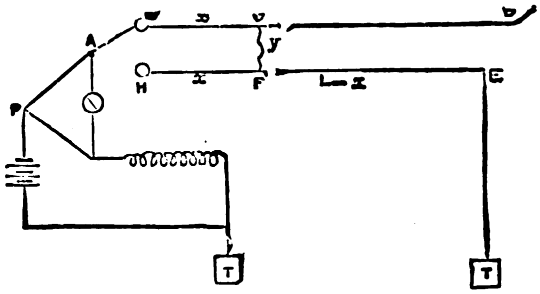
As follows from the above, the telephone is still capable of essential improvement; in a short time telephones will assuredly be constructed which will convey both speech and musical tones beyond comparison more loudly, more distinctly, and with greater purity to moderate distances than they have been hitherto by the Bell telephone. The telephone will then render service to intercourse in cities and between neighbouring towns which will far surpass what the telegraph can perform for short distances. The telephone is an electrical speaking tube, which, just like an ordinary speaking tube, can be managed by every one, and can be a perfect substitute for personal conversation; but, as at very short distances it will never supplant the speaking tube, just as little will it be able to take the place of the telegraph for greater distances. Yet, in the limited circle of its practicability it will soon be numbered among the most important pillars of modern civilisation, if external hindrances do not prevent its development and application.

* Foucault, on the 2nd of July, 1869, took out a patent in England for encasing the individual conductors with tin foil or other conducting substances, with the expressed purpose of compensating electrodynamic induction by the countercurrents arising in the tin casing.

DETERMINATION OF A POINT OF CONTACT BETWEEN TWO WIRES.

The formula for the localisation of a contact between telegraphic wires previously given in this journal (see *Electrician* July 20th), in addition to the simplicity of its application, has the merit of being independent of the diameter of the wires.

Expressing the resistance of the portion of wire B C (Fig. 1)*



in terms of that of the other wire, we get the two equations:

$$R = m x + y + L - x,$$

$$r = \frac{(m x + y) x}{m x + y + x} + L - x.$$

If in this latter we substitute the value of y obtained from the first equation, the quantity m x is eliminated, and we have

$$r = \frac{R x - L x + x^2}{R - L + 2 x} + L - x,$$

which, simplified as before, becomes

$$x = L - r + \sqrt{(L - r)(R - r)},$$

where x is the resistance of the length of wire between the station whence the experiment is made, and the fault, referred, therefore, always to the wire which has its further extremity put to earth.

It can also be demonstrated that the above formula is independent of the diameter of the wires in contact if we take the two resistances B C and y as a single one. Working out the calculations, we arrive at the same result. Yet another method might be adopted with advantage, which is expressed in a formula even more simple than the first, but it has the drawback of necessitating the alteration of one of the communications at the distant stations. The following explains this second method:—

The resistance B C F E is measured as before, and results in $R = L + y$. The further extremity of the wire H E is then also insulated, and the communications being disposed as shown in the cut, the resistance of the complete circuit B C F H is taken. This will be expressed by $r = 2x + y$. Subtracting from this last the former resistance, we obtain $r - R = 2x - L$; and thence $x = \frac{L + r - R}{2}$.

From this formula we at once perceive that, if $r = R - D$, $x = \frac{L}{2}$, or, in other words, that the fault is half way down the line. If $r > $ or $< R$, the point of contact is respectively beyond or before the middle of the line.

The general formula of Schwendler for determining the distance of a contact between two wires of different diameters is as follows:—

$$x = \frac{r - \sqrt{(L m + L' m' - r)(R - r)}}{m + m'}$$

where L is the length in miles of one of the wires, m its resistance per mile, L′ the length of the other wire, m′ its resistance per mile, r the resistance of the complete circuit when the two wires are insulated at the further extremities, and R the resistance of this circuit when the two further extremities are united. This method of Schwendler has the advantage of not comprising the earth within the circuit, but it cannot be expressed in a simple form.—F. CARDARELLI, in the *Elettricista*.

* In this diagram, for Fig. 1 A H should be joined by a dotted line; for Fig. 2 the earth-plates T should be removed.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

We cannot undertake to return drawings or manuscripts, and must, therefore, request Correspondents to keep copies.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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We shall be happy to exchange with the Editors of Scientific journals who receive the first numbers of THE ELECTRICIAN.

Nous serons heureux de faire l'échange avec Messieurs les Rédacteurs des Journaux scientifiques qui recevront les premiers numéros de L'ELECTRICIAN.

Es wird uns ein Vergnügen sein mit den löblichen Redactionen der deutschen und anderen continentalen Journäle und Zeitschriften, denen die ersten Nos. des ELECTRICIAN *zu Händen kommen möchten auszutauschen.*

I Signori Editori di giornali scientifici che riceveranno i primi numeri dell' ELECTRICIAN *ci faranno cosa gradita accettando il cambio che loro offriamo.*

CHEAPER POSTAL TELEGRAMS.

Appetite comes in eating, is a well-known French aphorism, which might be applied to telegraphy. There is no satisfying a generation which, though it may remember the time when it was glad to have the accommodation of a ricketty coach that ran twice a week at the rate of six miles an hour, now grumbles if it has to wait twenty minutes for an express train to Charing Cross. So, the country has scarcely settled down to the enjoyment of its telegraphic facilities before it is actually crying out for "more," to the great scandal of the official mind. The day of sixpenny telegrams will come, we are assured by Mr. W. H. Preece, as spokesman for the Department which he declares to be such a praiseworthy department. But that bugbear of all departments, the public, is beginning to ask somewhat impatiently why man never is, but always to be blest in this particular. And, as soon as the day of sixpenny telegrams may be pronounced to have come, the next thing will be an agitation for twopenny telegrams. In these days of progress these is no peace even for the most righteous department.

We do not wish to be unreasonable or over hasty in complaining of the Department which has undoubtedly done so much for us, and, under the gentle pressure of public opinion, is going to do so much more. We desire to keep in mind that the institutions of writers for the Press are as easily managed as old maids' husbands, or bachelors' children. Yet we cannot but remember that there is such a thing as "officialism," which becomes generated in the management of every department, and produces an atmosphere unfavourable for the growth of improvements; moreover, that some traces of this element have lately been detected in the spectrum of Mr. Preece's model department, and it is in the nature of things that, where the spur of competition be absent, a well-stalled department, secure of hay and corn supplied regularly, is none the worse, as it jogs along, of having frequent intimations as to the public's opinion of its rate of progress. Eternal criticism is the price of monopoly.

It is agreed that the sender of a twenty-word message, with address uncharged for, seems at present to be liberally dealt with in point of quantity; if anything be in fault, it is a too high minimum not in accordance with the ordinary requirements of a telegraphic message. On the other hand, it will not be denied that, if the strain could be taken off the telegraphic system at certain points, cheaper messages could be sent without loss. Mr. Preece admits that sixpenny telegrams would pay with a smaller number of words allowed; and most business men would accept such a concession as a fair one. The practice of other countries suggests three ways of more equally distributing the pressure. The first is a rate per word, with a small minimum charge to cover expenses which are the same for every telegram. The second is a lower charge for messages within a certain zone. These two methods have recently been united in France by the establishment of a reduced charge for messages from one part to another of any department, the minimum being half a franc for ten words, inclusive of names and addresses, which are shorter there than with us, as the sender only signs the message with his surname. The pecuniary results of this change have been pronounced by the French Department most satisfactory. The third plan is to have two classes of telegrams, a double charge being made for "urgent" messages taking priority over the others. In Belgium, a densely populated and commercial country like our own, these "urgent" telegrams, including all sent at night, were only $2\frac{1}{2}$ per cent. of the whole traffic, a small proportion which is the less surprising as nearly three-fourths of the ordinary telegrams were delivered under half an hour from the time of their despatch.

How far any of these methods, or a combination of them, would answer the end in view, must be referred to the experience of the officials who best know all the circumstances of the case. But we hope they will give most careful attention to a reform advocated by Sir Julius Vogel, late Prime Minister of New Zealand. In *The Times* and the *Nineteenth Century* he makes a suggestion which appears to us most practical and simple. It is to establish two classes of telegrams at separate rates, one, as now, to be despatched by special messenger, the other to be more cheaply sent out by the next postal delivery. The present system of delivery is most expensive, is an obstacle to the extension of telegraphic business, and is not always an advantage to the recipient of a message, especially if he have to pay a heavy extra charge for living at a distance from the nearest station. It is obvious that many if not most of the cases for telegraphing would be met by the machinery of the Post Office when once the space between town and town had been disposed of. One may frequently require to communicate with Belfast or Aberdeen in something less than a day, but without a few hours' delay making any difference. In the case of country telegrams, it is often the postman that carries them, after all, while no diminution of charge is made. In large towns the Post Office deliveries are or could easily be made as rapid as would be necessary for the delivery of nine telegrams out of ten. This article, posted in a London suburb at 2:15, reaches the office of THE ELECTRICIAN in two hours; and, if all stories be true, the Department's Ariel is not always more expeditious, especially if a Punch and Judy show or a friend's pegtop be interposed in his circuit. But, if a large proportion of messages be thus dealt with by the ordinary channels, the urgent telegrams at special rates would not be delayed so commonly or so excusably.

Not the least merit of Sir Julius Vogel's proposal is, as he points out, that it would increase the efficiency both of the

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Postal and of the Telegraphic service, for not only could the special delivery be facilitated, but the Post Office might gradually establish more frequent and rapid deliveries of all classes of correspondence, while in the meanwhile no "risk attaches to a trial of the plan, so far as relates to a difference in the charge between delivery by the Post Office and by messenger. It involves no extra staff, excepting that which its own success makes necessary. If it answer, and the public use it, the present system of delivery will be lightened and the Department will gain. If it does not answer and the public do not use it, no harm will be done." So we would respectfully ask the Department what objection it can make to this plan of making the present system more elastic. If its only reply be that certain lines, perhaps those most likely to be affected by the change, are already over-crowded, and certain clerks already overworked, we can but express our deep sympathy with it in its difficulties, and recommend its heads to consult any enterprising private tradesman who can, no doubt, instruct them how to act under the remarkable misfortune of a great and growing increase of business.

GENERAL CONSIDERATIONS ON TELEGRAPHIC TARIFFS.

[CONTINUED FROM PAGE 197.]

These rules laid down, let us ascertain the extent to which they have been followed in the construction of the actual international tariff, and in the resolutions adopted by the Telegraphic Conference at St. Petersburg. Considering the financial position of the majority of the contracting offices, these resolutions were bound to preserve, in general, the net profits derived from the existing tariffs. They could, therefore, only lower the price of certain messages whilst making compensation elsewhere.

On the other hand, the raising again of the international charges was to be avoided, not only because all augmentation is unpopular and to be regretted, but also because the respective parts of the international tariffs are, as a rule, higher than the tariffs for the interior, and because there is no margin to augment still further the profits derived from the former.

The solutions which have been proposed have reference to two classes of ideas, which may be formulated as follows:—The *rate per word* and the *differential treatment* according to the nature and the importance of the despatches.

Let us first consider the advantages attributed to the rate per word:—

1st. To accord to the public the facility, very beneficial to commerce, very advantageous for the utilisation of the lines, very fruitful to the revenue, of short despatches at a low rate.

2nd. To avoid, in the progression of rates, the too great step resulting from the surcharge of fifty per cent. for every word after the first twenty.

3rd. To avoid the useless overcharging of the wires, arising from the unnecessary words which the sender adds in order to complete his twenty words.

The three-fold advantage set forth in the first case is subordinate, above all, to the quota to be received for each word.

No one has upheld the idea of charging for each word merely the twentieth of the actual price for 20 words. It has been established, by probabilities which have not been contested, that by charging *a fifteenth* there would be a loss, for an equal number of telegrams, of 9 to 10 per cent. It is true that the lowering of the charge for short despatches would increase their number; but, on the other hand, the telegrams of about 20 words overcharged by a third would have been diminished by the same cause. The general effect upon the movement should be the result of the mean reduction. The latter being about 10 per cent., there would have been about 5 per cent. of telegrams in addition, and a diminution of the gross receipts of about as much.

These results arose from the programme established at the Conference of 1875, for they make, at the same time, a diminution of the gross receipts and a sensible raising of tariff for the telegrams of 20 words. It was then alleged that the rate of a thirteenth or of a twelfth would evidently be remunerative. This statement does not appear to us proved, for in a short time the messages per word with the United States of America have arrived at an average of 11 words per telegram. But it seems to us fair to discuss the rate per word under the most favourable conditions in which it may have been put in practice, and these conditions are found to be realised, in our opinion, in the new tariff of the German Empire. This tariff consists of a fixed charge of 20 pfennig, to which is added five pfennig per word.* These two elements represent respectively the one-fifth and the one-twentieth of the charge of a mark, which was made before the 1st of March, 1876, for 20 words, for the mean zone of the Empire. Comparing them to, for example, an international tax of 3f., they would be proportionately 60 and 15 centimes, and they would produce for 16 words, the actual tariff for 20 words.

At the tariff of 3 francs per twenty words, we reckon upon 100 telegrams:—

86 telegrams	up to	20 words	@ fr. 3	=fr. 258
9 ,,	from 21 to	30 ,,	,, ,, 4·50	= ,, 40·50
3 ,,	,, 31 ,,	40 ,,	,, ,, 6	= ,, 18
1 ,,	,, 41 ,,	50 ,,	,, ,, 7·50	= ,, 7·50
1 ,,	,, 51 ,,	100 ,,	,, ,, 12	= ,, 12

Total charges for 100 telegrams = fr. 336

The tariff per word would modify these figures in two ways:—1st, by rendering the telegrams shorter; 2nd, by stimulating the traffic below 16 words, and by depressing it from 16 to 20 words, by the two opposite effects of a reduction and an increase of price.

Judging from what we know, there would be, upon the 86 telegrams above, 72 telegrams from 5 to 15 words; mean number of words 10, and mean tax 2fr. 10c. At this rate it would need 103 to regain the gross receipts of 216fr. (72 × 3). There would be obtained then 87½.

Four telegrams of 16 words would, again, be found with the same charge of 3fr.

Ten telegrams from 17 to 20 words (mean 18 words) would be charged at 3fr. 30c.

At this rate it would only need 9 to regain the gross produce of 30fr. We could then suppose them reduced to the number of 9½.

The 9 telegrams from 21 to 30 words being charged, according to a mean of 25 words, at 4fr. 35c. (instead of 4fr. 50c.), their number would not be modified in an appreciable manner. The same would be the case with those following, and the 100 telegrams producing 336fr., according to the actual tariff, would be replaced by the following traffic:—

87½ telegrams	from 5 to 15	words at	20f. 10c.	mean, 183fr. 75c.
4 ,,	,, 16	,,	3fr.	,, 12fr.
9½ ,,	,, 17 to 20	,,	3fr. 30c.	,, 31fr. 35c.
9 ,,	,, 21 to 30	,,	4fr. 35c.	,, 39fr. 15c.
3 ,,	,, 31 to 40	,,	5fr. 85c.	,, 17fr. 55c.
1 ,,	,, 41 to 50	,,	7fr. 35c.	,, 7fr. 35c.
1 ,,	,, 51 to 100	,,	11fr. 85c.	,, 11fr. 85c.

Total charges for 115 telegrams .... 303fr.
Equivalent for 100 telegrams .... 263fr. 50c.

This, then, would be equivalent to a reduction of 3fr. 36c. to 2·635 per mean telegram, and the result would be a diminution of gross receipts from 336fr. to 303fr. (10 per cent.) in transmitting 115 telegrams instead of 100.

But these 115 telegrams are shorter. Let us see what would be the economy of labour. Although useless words may be sometimes added to complete the number of 20 words, there are in point of fact a great number of telegrams charged at the minimum which do not attain that length. According to our observations, they are sufficient to compensate for the words above 20 in the surcharged telegrams, and the general mean, in the international relations, is 19·95 words per telegram. This would give then 1,995 words for 100 despatches.

Our 115 telegrams above only admit of 1,560 words. But for both it is necessary to take into account the ordinary preamble, equal to nine words, the optional office repetitions, the accessory information, explanations that would be estimated at least at three words on an average per telegram. There would be then 1,200 words to add to the 100 telegrams of the actual system, and 1,380 words to the 115 despatches calculated from the supposition above, say respectively, 3,195 and 2,940 words.

* The advantage of a fixed charge consists in not reducing unduly the short despatches at the expense of the telegrams of 20 words and over. The problem is solved as well as is possible by the combination adopted in Germany, for there is only a light surcharge from 17 to 20 words, of 27 to 30, of 37 to 40, &c. Only it follows that the cheapness below 16 words being without compensation above, the tarification per word in itself can but diminish the produce in a great proportion. If it is otherwise in Germany, it is the result of the unification of tariff which does away with the first zone, in which the telegrams were very numerous and very cheap. In the interior system of Italy a minimum of one franc for 15 words is augmented by 10 centimes per word beyond 15. This gives 1·50fr. for 20 words, like the German tariff, but for longer despatches the Italian tariff is sensibly higher. It would be very interesting to obtain a comparative study of the effects of this tariff on the traffic, but it would be necessary to distinguish therein the results of lowering the charges from those which can be attributed to the gradation per word by itself.

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The 336 francs of the actual system render a return of 10½ centimes per word, and the 303 francs on the hypothesis render 10·3c. per word, that is to say a result sensibly the same.

Reverting to the three advantages enumerated, in the first place, by the partisans of the rate per word, we recognise in the first place *the benefit to commerce of short despatches*; only this benefit applying to a category of messages, which are transmitted in any case, whatever may be the charge, we think we have rather exaggerated the stimulating effect they would have in augmenting the traffic.

The advantage in regard to the utilisation of the lines would be reduced to zero, the gross produce per word remaining the same. There would be for short despatches the same expense for the operations of transmission and reception, especially for the delivery at the addresses of the receivers. With regard to the effect upon the revenue, it is expressed by a loss of 10 per cent. upon the gross receipts.

And if we are told that the tariff taken as an example is badly selected, that we have exaggerated or not taken into account the consequences, we reply that experience will move always in the same circle, consisting in reducing the mean charge per telegram more or less than we have done. In reducing it more, the advantage would be greater to the public and the loss greater to the receipts; in reducing it less, these two contrary effects would be lessened. Or else it is possible to aid the short despatches by surcharging the long, by striking at family messages and those of the Press,* which do not admit of abbreviations, or language previously agreed upon, &c.

The advantage No. 2 (to avoid undue surcharge for a word or two above twenty) is more apparent than real. The number of words in a telegram is not determined by an inflexible rule, and the careful sender never gives out a despatch of 21 or 22 words. It is true that there is attributed to the rate per word a particular *prestige*, in virtue of which senders would cease restricting themselves, and would allow their pen to write without counting their words, because the increase for a word more would have become insignificant.

We admit, in effect, that the gradation per word would give that which does not exist now, telegrams of 21, 22, 31, 32 words. But the benefit accruing therefrom would be largely balanced by the cheaper classes of telegrams, where careful people would well know how to make a saving.

The advantage No. 3 is real, but it is very difficult to define the extent of it. Are the words added numerous? Are they altogether useless? Do they not represent for the correspondents a satisfaction sufficient to justify the occupation of the wires several seconds longer? We will not search for the solution of these questions. The rate per word, although it does not proportion exactly the remuneration to the service rendered, nor to the cost price of this service, has the merit of coming as near as possible to that proportionality, especially by means of a fixed quota, as in the German tariff for the interior. This merit would be decisive if it were not destroyed by some serious inconveniences. We have just shown the impossibility of maintaining the gross receipts and especially the net product without surcharging considerably the telegrams of 17 to 20 words. But this disadvantage is not the only one.

[TO BE CONTINUED.]

* According to observations made upon the international despatches which have circulated in Belgium, there would be, upon 100 telegrams destined for the Press, 39 despatches of more than 20 words. The general proportion being 14 per cent., it is evident that for this class of messages, which interests essentially the mass of the public, the tariff per word would have only disadvantages, unless accompanied by a general lowering of prices recognised as impossible at the present moment.

SOME EXPERIMENTS AND DEDUCTIONS IN ELECTRO-METALLURGY OF LEAD.†

BY N. S. KEITH, NEW YORK CITY.

Let us take a jar and nearly fill it with a mixture of sulphuric acid (H_2SO_4) 1 part, and water (H_2O) 10 parts. In this mixture we will put a rod or plate of zinc. Immediately bubbles of hydrogen form upon the zinc, and, rising, escape. We notice that the liquid increases in temperature, and also its gravity increases. As heat implies motion, evidently there is force active in the liquid. This action we have called an evidence of chemical affinity; the attraction or affinity which Zn has for SO_4. And as Zn is bivalent, it displaces H_2 from H_2SO_4, and forms Zn SO_4. As each chemical action has its specific dynamic equivalent, either setting free, or, in other words, making active, a specific amount of force, or, on the other hand, absorbing or making latent a specific amount, we can express the action in foot-pounds, and also in heat-units.

† In *Engineering and Mining Journal.*

These foot-pound values have not been absolutely determined, different investigators arriving at different figures; but they agree upon the facts, though not exactly on the figures. For the sake of illustration, I will use approximate round figures, and say that the union of a grain-equivalent (31·75 grains) of zinc with a grain-equivalent of SO_4 sets free 10,500 foot-pounds of force. The time is the time of the action, so that it may be 10,500 foot-pounds per second, minute, hour, or other time.

But the setting free of hydrogen absorbs force, renders it latent; this is also specific, and may be stated at 6,800 foot-pounds. Deducting then, from the 10,500 foot-pounds set free by union of Zn with SO_4, the foot-pounds of force absorbed by freeing H, and we have 3,700 foot-pounds of active force, which, divided by 772, gives the number of heat-units of this chemical action and reaction.

So, then, we have in activity in this arrangement of matter so many foot-pounds per grain-equivalent of chemical action which we can, by further connected arrangement of matter, use for various purposes, such as heat, magnetism, chemical action, mechanical motion, &c.

Now this action is local. To make it useful, we must provide a circuit or path for it; and upon the character of that circuit depend the various manifestations which we call electricity, magnetism, electrolysis, &c.

Take now a plate of copper, and put it in the jar; and having amalgamated with mercury the zinc plate, put that in the jar also, the copper leaning against one side and the zinc against the other. Connect them, externally to the liquid, by a copper wire, and we have a complete galvanic battery of the Smee type, not in perfected form, however. Now the hydrogen bubbles rise from the copper, and they will continue until, if our zinc plate is heavy enough, the H_2SO_4 has lost all of its H, and Zn has taken the place of the H, leaving us a solution of Zn SO_4. Now no more bubbles arise, no force is set free from Zn, and none absorbed by H. The chemical affinity is satisfied, and the 3,700 foot-pounds per grain-equivalent is the measure of the greater affinity which Zn has for SO_4 than H has; it is the dynamic equivalent of that arrangement of matter, and is the measure of the active force available for work.

We can also say that zinc is electro-positive to hydrogen in this case, as it has a greater affinity for SO_4, and is so much so by 3,700 foot-pounds per grain-equivalent.

Our arrangement has become inactive because there is no more SO_4, combined with H. The affinities are satisfied. But if we put some sodium in this solution of $ZnSO_4$, Zn will be displaced by Na, as Na is electro-positive to Zn, and that, also, by a certain number of foot-pounds per equivalent. Thus it is from oxygen to potassium; each element is electro-positive or electro-negative to others in the proportion of its or their greater or less foot-pound equivalents. Though this relation in various arrangements is pretty well defined, the exact numerical values are not determined for unqualified acceptance.

Now, we will take another jar, amalgamated zinc plate, copper plate, and mixture of H_2O and H_2SO_4, and place alongside of the first, and by a wire connect the two coppers, and with other wires connect the two zincs through the galvanometer G. There is no deflection of the needle of the galvanometer. Why? There is a complete circuit!

If we lay a piece of wire across from copper to zinc of No. 1, immediately there is a deflection, but no electric current through No. 1. The force is exerted when active in the direction from zinc through liquid to copper, and completes the circuit through the external connections back to zinc. Now these are in opposition, and are equal, so no force is active, no copper of cell No. 1 is dissolved. But let us change the wires so that the zinc of each is connected with the copper of the other, and the galvanometer needle is deflected, and we observe the following phenomena: Zinc of No. 2 is dissolved, hydrogen bubbles from its copper, zinc of No. 1 is dissolved and its copper is covered with zinc. No H from No. 1 as there is no H_2 SO_4 to decompose; H_2O not being an electrolyte.* The whole circuit is raised in temperature in equivalent to the amount of zinc dissolved in No. 2. The same amount of zinc dissolved in No. 2 is dissolved in No. 1, and the same amount is deposited on the copper of No. 1, while an equivalent of hydrogen is set free at the copper of No. 2.

This may seem very elementary, but it is useful in so far that it enables us to graphically express the electric chemical relations of some substances as types of all others. There is no action in the first arrangement of two cells, because their affinities are balanced thus:—

Let the sign + mean positive or active; and the sign — mean negative or latent.

* We think this statement incorrect, and that water must undoubtedly be classed amongst the electrolytes, although (when pure) it offers a very high electrolytic resistance.—ED. E.

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+ Force due to union of Zn with SO_4 in No. 2...	10,500 ft.-pounds.
+ " " " Cu " " 1...	6,000 " "
	16,500 " "
+ Force due to affinity of Zn with SO_4 in No. 1.	10,500 " "
+ " " " H " " 2.	8,900 " "
	19,400 " "

The —, or latent force, being in excess, there is no current

As the copper plate of No. 1 is immediately covered with a deposit of Zn, it becomes, in effect, exactly as though two zinc plates were immersed. So we have:—

+ Force due to union of Zn with SO_4 in No. 2...	10,500 ft.-pounds.
+ " " " " " 1...	10,500 " "
	21,000 " "
— " " of H_2 " " 2...	8,900 " "
— " " of Zn " " 1...	10,500 " "
	19,400 " "

Leaving an active force of 1,600 foot-pounds. As the + and — forces are equal in No. 1, no force is absorbed by the chemical analysis and synthesis taking place therein.

Now, for the application of these principles to the separation of metals, more especially, at this time, to the refining and desilvering of lead base bullion by the process devised by me, and described July 13th, 1878.*

As lead is, by far, the largest part of base bullion, holding alloyed the other metals, such as are here named, with their various foot-pounds of force of union, with chlorine, in a solution of lead chloride, approximately stated in round numbers, it must of necessity be the metal to be dissolved, and deposited.

Antimony	1,500 foot-lbs.	per	129·00 grains.
Silver	2,000 "	"	108·00 "
Copper..................	7,000 "	"	31·75 "
Iron	7,500 "	"	28·00 "
Tin	8,000 "	"	59·00 "
Lead......................	8,800 "	"	103·50 "
Zinc......................	10,000 "	"	32·6 "

Taking now a solution of lead chloride, in say six jars, though more may be used, but not necessarily for this illustration, and a proper number, as hereinafter stated, of rods or plates of each of the above metals, and say a "gravity cell" for the source of active force, and some wire for connections in making the circuit, and a galvanometer, we will make some experiments.

The active force of our gravity cell is the difference in affinities for SO_4, which are specific to zinc and copper, say 10,500 — 5800 = 4700 foot-pounds per 32·6 grains of zinc dissolved, or 31·75 of copper deposited in it, or, in other words, 4700 foot-pounds, which is expressed electrically as 1·08 volts; a volt being 4673 foot-pounds.†

Making up our circuit now by putting pure lead for the + and — plates in the jars, the active force (electric current) in the circuit having its source in the battery causes the solution of lead at + and deposition of lead at — throughout the whole number of jars, and in equivalent proportion in each to the amount of zinc dissolved in the battery. Our galvanometer needle is deflected N. pole to the right.

Now we will make the + plates of base bullion, and still lead is dissolved and deposited in the same proportion; but we observe instead of a clean crystalline surface, as in the pure lead + plates, an accumulation on the base bullion + plates of a dark metallic powder, consisting of the various impurities of the bullion except zinc.

A few experiments will show the reason for this accumulation. Take first some tin plates, and one after another put them each in the place of a lead + plate. After each substitution we notice the deflection of the galvanometer is less, until, when we have changed four + plates, the deflection is nothing; there is no current. So with copper; current passes through two copper + plates, but not through three. With silver through one, but not through two. The reason is that the negative force of the lead — plates exceeds the + force of the + copper plates, added to the + force of the battery, thus:—

— force of affinity of lead for chlorine, at three — plates, is 8,800 × 3 = 26,400 foot-pounds, against which we have + force of union of copper and chlorine at three + plates = 7,000 × 3 = 21,000 added to 4,700, force of battery = 25,700 foot-pounds + force, which is less 700 foot-pounds than the — force. The — force of two lead — plates exceeds the + force of two + silver plates added to the + force of battery; so no current passes, and there is no chemical action.

So it might be supposed that a current would pass in the opposite direction. Open the circuit and put in three copper or two silver + plates, free from any deposit, and on making circuit, the galvanometer needle will deflect to the *left* instead of to the *right* as before, showing a current in the opposite direction. But it is only for an instant, and settles at once to zero.

So with a battery or dynamo-electric machine having no more electro-motive force than one volt, or, in other words, no more active force than 4,700 foot-pounds per grain-equivalent of chemical action, or its equivalent in mechanical force, we can dissolve no metal constituent of base bullion other than lead and zinc, if we have four or more vats for the purpose placed in series; consequently none of those metals will be deposited on the cathodes, to make the lead impure.

The question now arises:—Will zinc be deposited with the lead, as it is dissolved at the anode?

Substitute in four of our tumblers a solution of zinc acetate, and use base bullion + plates and lead — plates, we will find that we can pass current through three of these, depositing zinc, but not through four. Now pour into each of these four some solution of lead acetate, and immediately current passes, but only lead is deposited. Having two metals in solution, that one is deposited on the — plate which is electro-negative to the other, unless the solution in immediate contact with the — plate contains too little of the electro-negative metal to satisfy the current's depositing capacity. The current may be said to exercise a selective capacity, taking the electro-positive metal at the anode (+ plate) and depositing it at the cathode (— plate) if there be no metal electro-negative to it in solution. So zinc is sure to be dissolved at the anode; but, as it is only in small quantity, and cannot satisfy the current, the next electro-positive metal, lead, is dissolved. At the cathode, lead being in quantity to satisfy the requirements of the current there, and being electro-negative to zinc, it is deposited while zinc remains in solution.

But we can electrically deposit zinc, replacing it by lead, in properly-arranged vats. As the percentage of zinc is small in base bullion, especially after melting at low heat, and removing the dross as described about the process, but little of this zinc separation will be necessary, and the zinc product will pay the expense attendant upon it.

Now, a final experiment. Current passing through the solutions as last arranged, the deflection of the galvanometer needle is 40° to the *right*. We substitute one zinc plate for one — lead-plate, and the deflection is 34° to the *right*. With two such plates the deflection is 27° to the *right*. With three, 12° to the *right*. With four, 2° to the *left*; showing that the four negative zinc plates exert more force than four + base bullion plates added to the + force of the battery. Thus:—

4 times 10,000 foot-pounds — force zinc	40,000
4 " 8,800 " " + " lead	35,200
4,700 " " + " battery.........	4,700
	39,900

I have only given the force due to the metals under consideration their approximate values. The correct values are yet to be determined. They are certainly needed for exact calculations and operations in electro-metallurgy. Who will make the measurements?*

[* We believe these measurements have already been made, and we hope the author will publish his results shortly.—Ed. Electrician.]

CORRESPONDENCE.

BATTERY RESISTANCE.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Mr. O. Lodge says, in his paper in *The Electrician* on "A Modification of Mance's Method of Measuring Battery Resistance," that "it is impossible to measure the resistance of a battery without varying the strength of the current passing through it." Now, in last week's number (No. 18) there is an article on a "New Method of Determining the Current Elements of a Voltaic Circuit," and I think it will be seen that, by this plan, it is *possible* to do what Mr. Lodge affirms to be *impossible*.—
I am, &c., A. C. M. W.

*** Toy on "Telephony" next week.

Accident to a Telegraph Steamer.—Lloyd's agent at Singapore, in a telegram dated September 24, 5:5 p.m., reports that the British steamer *Edinburgh* had gone ashore there, but would probably be got off without damage. The steamer referred to in this telegram belongs to the Eastern Extension, Australasian, and China Telegraph Company, London. She is an iron A 1 steamer, built at Glasgow in 1855, and her dimensions are:— 1,817 tons net, 2,315 gross, and 2,082 under deck. The steamer is stated to have been on her way to Penang to repair the telegraph cable when she met with the mishap.

* This application will be given in a future number.

† The Volt, being a unit of *Force*, cannot possibly be measured in foot-pounds, *i.e.*, by the unit of *Work*.—Ed. E.

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STUDENTS' COLUMN.

Geometrical Representation of the Relation between the Electromotive Force and the Resistance of any Combination of a given Number of Cells.

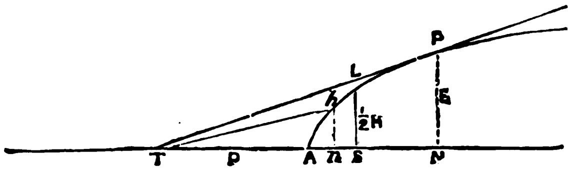
BY OLIVER J. LODGE, D.SC.

The problem of finding the best arrangement of a given number of cells with a given external resistance is a very common one, and the result well known, viz., that the best arrangement is obtained by making the internal resistance equal to the external as nearly as possible. The following is an interesting and comprehensive way of putting the matter.

Let there be n similar cells arranged anyhow into a battery, each cell with E.M.F. e, and resistance r; the electromotive force and resistance of any definite combination of them being called E and R. Then the rate at which the battery can do work (generate heat, for instance), or its "power," is independent of the particular arrangement or combination, and is

$$H = \frac{n e^2}{r} = \frac{E^2}{R}$$

Hence the ratio between the square of the E.M.F. and the resistance of any combination is constant; and so the relation between these quantities may be exhibited in a parabolic form, the equation $E^2 = HR$ corresponding to the equation to a parabola in the form $y^2 = 4ax$.



The E.M.F.'s of different combinations are represented by the ordinates, and the corresponding resistances by the abscissæ, of a parabola whose latus rectum is H—the *power* of the battery. ["Power" is defined as rate of doing work—so many *ergs* per second—"horse-power" is a case of it.] In the figure, S is the focus, S L half the latus rectum $= \frac{1}{2}H$; and, if A N represents R, the resistance of any arrangement, P N will represent E, the corresponding E.M.F. If A n represents the resistance, then, of course, $p\,n$ is the E.M.F$_1$, and so on. Also, if the external resistance of the circuit through which the current is sent is represented by a length A T drawn opposite to A N, and of course to the same scale, then the angle P T N is proportional to the angle of deflection of a tangent galvanometer in the circuit, the tangent of this angle being the strength of the current. This angle is evidently a maximum, for a given external resistance ρ, when the line T P *touches* the parabola; and, in that case, by known properties of the parabola, A N = A T; or the internal resistance must, to give the maximum current, be equal to the external (R = ρ), showing that this is the best arrangement.

Practically, R can only vary by jumps between the limits $\frac{r}{n}$ and $n\,r$. The values of R possible are these, with the squares of the natural numbers as denominators:—

$$n\,r,\ \frac{n\,r}{4},\ \frac{n\,r}{9},\ \frac{n\,r}{16},\ \frac{n\,r}{25},\ \&c.,$$

any term being struck out if the number whose square occurs in its denominator does not divide n integrally; hence the series practically stops as soon as the square of n itself occurs in the denominator.

But it may be made to terminate before this. The shortest plan is to start with two series:—

$$n\,r,\ \frac{n\,r}{4},\ \frac{n\,r}{9},\ \&c.;\ \text{and}\ \frac{r}{n},\ \frac{4\,r}{n},\ \frac{9\,r}{n},\ \&c.,$$

and stop directly the two series overlap. This they will do directly the number occurring in the denominator of the first and in the numerator of the second exceeds or equals n. The terms that will have to be struck out of these two series will not now be numerous if n is a reasonable factor-containing number. Thus, the six terms written above give all the possible arrangements of twelve cells without any striking out; a continuation of either series leads to repetition. With thirty-six cells the series would not overlap till the term $\frac{n\,r}{36}$; but the terms $\frac{n\,r}{25}$ and $\frac{25\,r}{n}$ would have to be struck out because 5 does not divide 36 without a remainder. If n = 60, there would be twelve possible combinations, the only term requiring cancelling being the last, involving the square of 7. The number of possible arrangements must always be less than 2 $\sqrt{n}$ if n be even, and $\sqrt{n}$ if n be odd.

The number whose square occurs in any term of the above two series is, in the first, the number of cells *abreast*; in the second, the number of cells *in series*. The given number of cells will send the strongest current through the given resistance ρ when arranged $\sqrt{\frac{n\,\rho}{r}}$ in series and $\sqrt{\frac{n\,r}{\rho}}$ abreast. This is seen at once by choosing from the above possible values of R that one which most nearly equals ρ: by, in fact, finding x (the number *abreast*) from the equation $\frac{n\,r}{x^2} = \rho$.

PROFESSOR SILLIMAN ON THE ELECTRIC LIGHT.

Paris, July 27.—All the world—meaning Paris and her guests—have seen the magnificent illumination by the electrical lamps of Jablochkoff, unless, indeed, they have been so blinded by excess of light that they have seen nothing. A walk up the Avenue de l'Opéra on a dark night, from the Palais Royal to the Grand Opera House, or in the Orangeries of the Garden of the Tuileries, or along the shops of the Belle Jardinière, or by the Arc de l'Etoile, will dazzle the strongest eyes with the splendour and penetrating intensity of the great globes of opaline glass which temper the insufferable solar glare of the unprotected light. I never see these beautiful globes without being reminded of that familiar class-room experiment of the chemical laboratory when phosphorus is burned in a glass sphere filled with oxygen, and the critical point arrives when the whole glowing space is filled with the burning vapour of the volatilised phosphorus, and the blaze of glory for the moment seems above the brightness of the sun. So in these electrical lamps the same impression is made, save that the seconds of duration for the phosphorus are extended to hours for the electricity. Objects viewed by the electrical light are seen in their natural colours; and such is the effect of refraction and reflection in producing a general diffusion of light, that no deep shadows are seen, as was the case when only a single focus of unblenched electrical light was employed. The lamps are set so high that there is no occasion to look at them, except the fascination of the thing while yet the effect is a novelty. The whole street, to the tops of the loftiest houses, is ablaze with a flood of beaming light, which makes the streets seem like the scenes of some grand play at the opera. . . . Let the question of priority of invention, of superiority in form of construction, and of conflicting claims among all the inventors, rest for the moment; the grand and simple fact remains that, given any adequate source of mechanical motion and masses of soft iron properly mounted for revolution, and armed with an adequate amount of insulating copper wire, we come, from the simple multiplications on itself of that inconsiderable amount af magnetic force which exists in most soft iron, developed by simple rotation of the bobbins of such an apparatus, to such a volume and intensity of magneto-electricity as is limited only by the power of the mechanical motor at command, and by the inductive capacity of the soft iron masses within the environment of the insulated wires of soft copper, provided the revolution of the arbor is accompanied with suitable interruptions in the direct flow of the electrical stream. Without the use of technical language, and of good diagrams, which would be of little value without technical description, we can hardly make the subject more easy of comprehension to the average reader. What is the result? Consider the Gramme machine, for example—for we are in Paris, and the Gramme machine is, unfortunately, the only light-producing magneto-electric apparatus on exhibition. Weston has his machines here for electro-plating doing excellent work, but Wallace is not here, nor Brush, of Cleveland, and so America remains literally in the dark when she should have made a most conspicuous show of electrical illumination—only one more example of our too numerous shortcomings at this Exposition. But to return to the Gramme machine for our illustration. It is simple, powerful, and very compact. It has no delicate parts liable to derangement; it can be set up anywhere in a few hours without any foundation, and it can be worked for months without delay or interruption. Like any other machine of simple rotation, the wearing surfaces need lubrication. It occupies only a space of about 4 cubic feet, weighs about four hundred pounds, of which the copper bobbin weighs about seventy pounds, and has a diameter of seven inches, and requires two and a half horse-power to drive it, with 850 turns per minute. Such a machine develops an average illuminating power of about five thousand seven hundred candles. Its intensity depends on various circumstances of position, &c., and may vary between 2,400 candles and 8,400 candles, according to the mode of placing the carbon points with reference to the photometer. This is the type of the machine in use for industrial purposes, for practical daily work in the illumination of shops, railways, and streets. There is in the Exposition a form of the Gramme machine at work, which yields, on the authority of M. Fontaine, three times more light for equal quantities of matter in action than any of those which have before been tried in France, England, or elsewhere. This machine weighs 441 pounds, cost £60 (300 dols.), and yields a light equal to 30,000 candles. Notwithstanding its low price and wonderful performance, this machine cannot be commended for use, as the elements of durability are wanting in it. But of the form of the Gramme apparatus used in shops it is affirmed that several hundred of these machines have been at work all the past winter, some of them without interruption, for underground operations, without costing a farthing for repair or maintenance except for lubrication. In the great foundry of Ducommen, and in the shops of Sautter and Lemonnier, these machines have been constantly at work for four years without giving the slightest trouble.

I quote from a carefully-prepared statement of Messrs. Heilman, Ducommen, and Steinlen, the average cost per hour of four Gramme machines which have been run by them in their shops for four years. The charge

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for interest and depreciation is rated at 15 per cent. on the cost of four Gramme machines and the motor to drive them, viz.:—

	Pence Sterling.
Carbon pencils burned	8·38
Steam consumed	3·42
Attendance	2·85
Interest and Depreciation	43·45
Total cost per hour	63·08

In this case the moving power is only about a twentieth of the total cost, while three-fourths of the total is put to interest and depreciation. The parties whose results we have quoted estimate that the cost of an equal amount of light from gas to that supplied to their establishment by these machines would be double. But the question of relative cost involves many considerations, and must vary with circumstances, and especially with the cost of gas, which in this case is estimated at 7*s.* 6*d.* (1·75 dollars) per thousand feet. In Paris the cost of gas is the same to the private consumer, say 30 centimes per metre cube. The cubic metre is, in round numbers, thirty-five cubic feet; consequently the cost of Paris gas in American currency is 1·75 dollars (say 8·57 francs) per thousand. But the city pays only half that sum, in consideration of the monopoly and of their having an equal share in the earnings of the company after a certain sum—say 10 per cent. on the original capital—has been paid to the stockholders.

I am informed by M. Alphonse Barlet, the engineer in charge of the Belgian railways, that he has installed four electrical lanterns—with the old style of regulator—in the *gare* or station of the Bruxelles Railroad, at a total cost of 20,000 francs (say 4,000 dollars) for one Gramme machine, one eight-horse power steam-engine, eight regulators, two to each focus of light (*foyer*), and all the necessary conductors, &c. These four electrical lamps take the place of 120 gas burners (*becs de gaz*) each consuming 150 litres per hour (four and a half cubic feet). The light now obtained from these four electrical lamps M. Barlet estimates equal at least to what would be got from 500 such burners as he used before. But for a comparison of cost, the statement is made between the 120 burners actually used before and the electrical costs, with the general results that in the long nights, when the use of the illumination is for six to eight hours during about seven months of the year, the electrical light is cheaper than gas. But in the summer, with only two or three hours' use of the light, the electrical costs more than the gas light. The reason is obvious. The wages of the engineer and electrician are the same in both cases, and the interest on cost the same for the shorter as for the longer duration of the light. But, on the whole, the electricity was the cheaper and the light abundantly more than the gas gave. On the other hand, the Northern Railway station in Paris, which was illuminated by the electrical lanterns, has returned to the gas.

I remember well the excitement occasioned by the first appearance of the electrical light in the well-known sunrise scene of "Le Prophète," at the Grand Opera House at Paris in 1846. The regulator then used was devised by M. Deleuil, a well-known instrument maker at Paris; but his form of the regulator was soon replaced by that of Duboscq, which is an apparatus found to-day in nearly every physical cabinet. In all forms of regulator before the Jablochkoff candle, the unequal march of the two carbons had to be provided for by a mechanism which advanced the positive carbon twice as rapidly as the negative, so that the focus of light remained (or was intended to remain) constant. All forms of the regulator were destined primarily for the voltaic arc, and the difficulty of manipulating two carbon pencils was common to all forms of the apparatus. These difficulties have been in a great degree overcome by the ingenious device of the young Russian officer, M. Jablochkoff, who, by simply placing the two carbon pencils side by side, and insulating them by means of a thin plate of some refractory substance placed between them, has dispensed entirely with all forms of regulating apparatus.

Those who have not seen this very neat little contrivance will understand it if they consider a common lead pencil reversed—*i.e.*, its two wooden halves are the carbons, and the central lead is the insulator, only this insulator completely separates the two carbons in all their length. This pencil, or candle, as it is well called, is held in a pince or vice of metal, the two jaws of which represent the two electrodes. At the upper end of the pencil is a narrow bridge of carbon, which completes the circuit, and, like a match, is inflamed by the first impulse of the electric current, thus immediately setting up the ignition. After that the arc itself is the conductor, and the light streams out with its well-known brilliancy. Four of these pencils, or candles, are mounted in each of the glass globes, and so arranged that they are ignited successively as each one is consumed, the time for each being from one and a half to two hours, according to the thickness of the carbons. The light is not absolutely uniform. There are the well-known variations familiar to all who have experimented with the electrical light, and the violet rays which are so fatiguing to the eyes are often visible; and, as will be seen by this statement, the duration of the light is limited at present to eight hours. This last limitation can be probably removed by mechanical improvements, which it is needless to dwell on here; and the use of globes in which uranium-oxide is employed to give its feeble fluorescent tint will absorb completely the violet rays, without injury to the brilliancy of the illumination. But, taken as it is, with all its defects, and abating at discretion the too favourable statements of those who are interested parties, we must all agree, who have seen it here in Paris, that it is the wonder of the occasion; and that is saying much, for there are some other wonderful things here, of which, perhaps, the great balloon is the freshest novelty. But the use of the Jablochkoff candle involved the necessity of a novel construction in the Gramme machine, and in all other magneto-electric machines of a constant current in one direction. The reason is obvious. The positive carbon is consumed twice as fast as the negative, and this would be fatal to the use of the famous "candle." This difficulty could be met only by producing an alternating current, and this has been successfully accomplished by M. Gramme in his new machine. This has been easily reached by the use of a small magnetic machine, supplemental to the illuminating engine, which acts as a commutator, and which effects, at a velocity of 800 revolutions, a reversal of polarity—alternation of plus and minus—64,000 times in a minute. By this simple device the Jablochkoff candle burns with entire uniformity.

At this moment there are three models of the Gramme machine with alternating currents. The first supports sixteen Jablochkoff candles of "100 becs"—*i.e.*, of an intensity each equal to 100 gas-burners—consuming five cubic feet of gas, and yielding each 20 candles power. It may be safer to rate these burners at 15 candles, which would be the same as saying each Jablochkoff globe equals the light of 1,500 candles. But this is not what is meant by the statement here. It means that one such electrical lamp extinguishes 100 gas-burners; but it is claimed that the actual intensity of light provided is equal to much more than that, as M. Barlet states in his experience in the Bruxelles Railway Station. This first model of the Gramme machine requires an engine of 16-horse power to drive it, and costs, with its motor, 10,000 francs, say 2,000 dollars; it weighs 650 kilogrammes, say 1,500 pounds, and makes 600 turns per minute. The whole weight of copper induction wire in action is 103 kilogrammes, about 125 pounds. The second machine is good for six Jablochkoff candles, requires six-horse power to drive it, and costs, with its motor, 5,000 francs, say 1,000 dollars. It revolves 700 times per minute, and weighs 280 kilogrammes; the weight of copper wire in action is 40 kilogrammes. The third form of apparatus feeds four Jablochkoff candles of 100 becs each, requires four-horse power to drive it, and costs, with its motor, 3,500 francs, say 700 dollars. It revolves 800 times a minute, and weighs 190 kilogrammes, having 28 kilogrammes of copper wire in action. From this statement it appears that one-horse power is estimated for each candle of Jablochkoff, or each 100 gas-burners.

M. Gramme is now occupied on a fourth model, which is to feed two electrical lamps, and is much cheaper both in cost and driving power. The Holmes machine and the Gramme machine are alike in the relative position of the bobbins and the electro-magnets, both being alternating currents. By the simple substitution of a plate of plaster of Paris for the kaolin at first used for the separation of the two carbons M. Jablochkoff has, it is claimed, doubled the intensity of the illumination without any increase in the electro-motive force, and the cost of the apparatus has been reduced from 75 centimes to 50 centimes per hour for each electrical candle—100 becs—motive power and depreciation of apparatus not included. I cannot conclude this letter without reverting to the splendour of the electrical illumination of the new Avenue de l'Opéra, as seen from the balcony of the Grand Opera. The effect is magnificent, and at this moment there exists nothing in this city of splendid effects to be compared to this magical scene. The surroundings of the Opera itself—the most majestic theatre in the world—no doubt add much to the effect. There are in view about thirty of these electrical lanterns, a part of those near the Opera House being of the same form (a cone inverted) used by the Paris Gas Company, the others being the opaline globes already described. The vista is about two-thirds of a mile, and the effect incomparably finer than any show of artificial illumination ever before seen. It is the light for all public places where a high degree of illumination is desired, as in large shops, cafés, public gardens, theatres, avenues, &c. But it will not displace gas for domestic use, nor for common street lights. Great difficulties in the subdivision of the current are yet to be overcome. For the Avenue de l'Opéra I understand there are three steam engines, and that at present 200 meters is as far as the current is conveyed. But let us not too confidently predict the future of what is possible in this direction. Of one thing we may be certain—the Parisian Gas Company are wide awake to the public interest in this thing, and will not be slow to add it to their present vast system of works whenever it appears that both their own and the public interest make it desirable they should do so. But in Paris the use of gas in houses is a matter of much less moment than in America, for the old prejudice excludes gas both in London and in Paris to a great extent from domestic use. Candles, and carcel lamps burning colza oil, still shine in all the *salons* in Paris. When, then, we learn that the share of profits paid over to the city from their one-half interest in the earnings above 10 per cent. first paid to the Shareholders' Association last year amounted to the round sum of 8,000,000 francs, we can readily understand that the city will act with the company in aggregating any valuable improvement in public illumination to their existing franchises, and that they can well afford to do so even at a pretty round price. The present capital of the gas company is, in shares, 84,000,000 francs, and in debentures 111,745,000 francs, or in the total nearly 200,000,000 francs, or 40,000,000 dollars. The modest little capital of 7,500,000 francs which the electrical company represents would be only as dust in the balance to such a huge monopoly. It is interesting to note that the amount paid last year by the city of Paris for gas was 7,827,205 francs—a little less than the dividends received from the company. But it must be remembered that the tax paid into the city treasury by the gas company last year was 8,500,000 francs, and that the several water companies paid a little more than that—viz., 8,924,577 francs. By this shrewd arrangement the city of Paris annually gains net over all costs for gas more than 8,500,000 francs. When will the several gas companies in New York combine to pay the city as much for their monopoly? Probably not in the fragment remaining of this century.

LIGHTHOUSE ILLUMINATION.

NEW APPLICATIONS OF GAS AND ELECTRICITY FOR LIGHT-HOUSES, &c.*

By J. R. Wigham.

I. *The Quadriform Group Flashing Gas Light as used at Galley Head Lighthouse.*—Galley Head, a promontory on the coast of Cork, about midway between Cape Clear and the Old Head of Kinsale, is a point in the neighbourhood of which there have been several shipwrecks. The Commissioners of Irish Lights, therefore, determined to place the most distinctive and powerful light which they could obtain. With this view, and acting upon the advice of Dr. Tyndall, their scientific adviser, they adopted the quadriform group-flashing gas light, respecting which I now propose to say a few words.

It is, perhaps, known to some who are present that the Commissioners of Irish Lights were the first lighthouse authorities to make use of gas as an

* Read before Section G of the British Association: Dublin Meeting.

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illuminant for important lighthouses. They have done me the honour of adopting the arrangements and burners for the consumption of gas which I have devised from time to time. My aim has been to combine the greatest possible intensity with the greatest possible volume in the gas flames which I employed.

Before showing you these flames, I may, perhaps, be permitted for a few minutes to explain some of the steps by which I was led to construct gas burners for lighthouses in the form in which they are now used.

Up to the time of my first experiments only argand burners had been used for the combustion of oil in first order lighthouses; but when it was attempted to construct argand burners for *gas* which should be of sufficient dimensions to give the same light as those used for oil, difficulties as to smoke and chimney glasses interfered, and it became evident that some other method of burning gas must be sought for.

It occurred to me that if any plan could be devised by which the excess of carbon—the smoke—existing in rich gas flames could be turned to account as a means of increasing their illuminating power, a valuable desideratum would be obtained. I accordingly made many experiments with that object, and came to the conclusion that I could find no better basis for my efforts to that end than the ordinary well known fish-tail jet. The fish-tail jet, it is hardly necessary to say, is bored diagonally on opposite sides of a small internal cone. The streams of gas issuing from the orifices impinge against each other with considerable force, and the result is the thin sheet of flame with which we are so familiar. This flame possessing a large surface to which the oxygen of the air readily gains access, is in consequence rendered brilliant and comparatively smokeless. But on closely examining the flame of a fish-tail burner it will be seen that towards the top, where the force of the stream of gas is nearly expended, it is thicker and inclined to be smoky. The larger the bore of the burner the thicker the stream of gas, and (its pressure and quality being good) the greater the amount of unconsumed carbon. When a number of fish-tails are arranged so that the upper extremities of their flames touch each other, they run up (because of the absence of air between each jet) into very smoky tails; but the light they give when thus united is increased (with hardly any increased consumption of gas), much beyond the mere multiple of their single flames, as may be seen in a moment by bringing two fish-tails together. I made this peculiarity of the fish-tail available for producing a large flame of high illuminating power, and I devised this form of burner. I used in its construction double jets, by which a more effective combustion of gas is attained with less consumption for each jet than in the burners which I used in my earlier experiments. The principle of the double jet is not new, but I believe that the present form of its application is entirely so. It is exceedingly simple and may be explained by this ordinary gas burner.

It will be seen that the power of this burner is obtained by a peculiar arrangement of numerous fish-tail jets, and it is increased by suspending over the flame which they unitedly produce an oxidiser of talc or other material by means of which a current of air is brought in contact with its most smoky part, rendering it not only smokeless but exceedingly white. The combustion is also assisted by a bottom cone for equalising the current of air to the flame. The oxygen of the air is thus twice availed of, first, at the bottom of the flame, through the medium of the several fish-tail burners; and, secondly, at the top of it, where its action raises to a white heat the large quantity of solid carbon found there. This may be seen if I light a burner, which is one of the ordinary clear weather lighthouse burners, and show it to you without and with its oxidiser. I may say, in passing, that burners like this are superior to any form of argand burner in this important particular, that they require *no* chimney glasses, the breaking and cleansing of which often cause much inconvenience in lighthouse maintenance, to say nothing of their presenting an obstruction to the passage of the light of the flame to the dioptric apparatus. I have on the table a complete Irish lighthouse burner. It is so constructed that a light-keeper can increase the power of the light by five steps, according as the state of the weather may seem to require it, from the burner used in clear weather, consisting of 28 jets such as I have just lighted, to the second, third, fourth, and fifth fog powers, consisting of 48, 68, 88, and 108 jets respectively. The changes from one power to another can be made very quickly by the use of mercurial joints, as I shall now show you.

With respect to these fog burners at which we have just been looking, I may say that while we all know that there are fogs capable of obscuring any artificial light, and that even the sun's rays can but feebly penetrate dense fog, yet when fogs are not *very* dense, or when the weather is merely what is called "thick" (but sufficiently so to obscure ordinary lights), then it is that the mariner derives much benefit from powerful lights such as I have just shown you.

The power of the gas burner at which we have been looking is, of course, very much increased by the use of lenticular apparatus. I have here what is termed an annular lens of the kind used for revolving or flashing lights in first-order lighthouses. I will move it in front of the 28-jet burner. You will see how a beam the full size of the lens is made to traverse every part of the horizon.

If, instead of using this ordinary lighthouse lens, which is designed for an oil lamp flame 4 in. in diameter by 3½ in. high, I were to use a lens made to suit my large 108 jet gas flame, which is 12 in. in diameter by 8½ in. high, I need not say that the illuminating effect would be enormously greater. I trust that before long lighthouse authorities will sanction the construction of such lenses, and so gain the full benefit of the large flames which, so far as we know, gas only can produce.

Being fully convinced from long practical observation of the importance of using large lights in illuminating fog, I determined to push that principle to the utmost limit permitted by the lenses now used in lighthouses, and I devised a plan by which, in foggy weather, double, treble, and quadruple the power of the largest gas light and lens at which we have been looking can be obtained. This plan, which has been termed the biform, triform, and quadriform system consists in placing two, three, and four burners respectively vertically over one another, and making an arrangement by which the products of the combustion of the lower burners are intercepted and turned outwards so as not to interfere with the upper burners, while a supply of pure air is conveyed to each of them by cylindrical openings brought through the flues. The air thus introduced is sucked in briskly by the draught and much heated by its contact with the nearly red-hot casing of the internal flue. The illuminating power of each of the flames is thus materially increased.

That you may clearly understand the plan by which these lights are burned one above another, I have here arranged two such lights, and you will observe that so far from the upper being injuriously affected by the lower light, it is improved by the high temperature at which it is burned, and the constant supply of fresh air which is sucked in by the apparatus which I have described. Without this apparatus, you will see that the upper light has hardly any illuminating power.

I have here a model of the quadriform apparatus which I have erected at Galley Head. There are thirty-two lenses arranged in four tiers, eight in each tier. Each lens is of the size of this first-order lens, and one of these powerful gas lights is placed in the focus of each tier; thus there are four burners placed over each other. As the lenses touch each other the lights blend at a few yards distance and form a great pillar of light about 13ft. high by 3ft. wide, the illuminating power of which is calculated to be equal to nearly one million sperm candles. This great illuminating power, it is to be remembered, is so under the control of the light-keeper that only one-fourth of it is applied in clear weather, the other three portions being reserved for application as the weather thickens. This light is the largest in the world, and it ought to be a source of satisfaction to the Commissioners of Irish Lights to know that what they have done at Galley Head in furtherance of the benevolent work to which they gratuitously give so much anxious attention, is likely to be of much benefit to the sailor. Indeed, since the completion of Galley Head Lighthouse early this year, the Commissioners have received from the commanders of the great ocean steamers which pass Galley Head the most satisfactory testimonials as to its power and distinctiveness. Can it be believed that there are persons who have expressed doubts whether the illuminating power of the quadriform is any greater than that of *one* of its four component lights! To convince such sceptics, and to afford the members of the British Association an opportunity of judging of the effect of this light, a first-order quadriform apparatus will, by the kind permission of the Commissioners of Irish Lights, be exhibited in comparison with the ordinary light at Howth Bailey Lighthouse, between nine and ten o'clock on the evenings of Saturday, Monday, Tuesday, and Wednesday, the 17th, 19th, 20th, and 21st instant; and may be best seen from the circular terrace in front of Parry's Salthill Hotel, close to Salthill Railway Station, and also from Longford-terrace, Monkstown.

Before concluding, I should say that the light at Galley Head, besides being quadriform, is also what I have termed a "group-flashing" light; that is, the flashes from the lenses, instead of being single flashes, as usually exhibited at lighthouses, are each of them, by the continual extinction and reignition of the gas, broken up into four or five beams, which constitute a group of flashes recurring at regular intervals, thus presenting a very distinctive light for the guidance of the mariner. This is accomplished by the same clockwork machine by which the lenses are caused to revolve. The interval between the groups of flashes is one minute, the interval between the flashes composing each group is about two seconds, during which the gas is cut off; a very considerable economy in the maintenance of the lighthouse is the result, only about one-half the gas which would be used in an ordinary flashing light being consumed.

One word more as to these flashes. Just as the suddenness of the flash of a gun catches the eye, so the effect on fog, when large gas burners such as I have described are *suddenly* lighted is very striking; and the use of gas as an intermittent light for lighthouse purposes is valued, not only because of its economy (the intermissions being due to the cutting off and consequent saving of the gas), but also because of its illuminating effect on fog by the sudden exhibition of its great light, as I have just mentioned.

II. *The Combined Gas and Electric Light for Lighthouses.*—The dimensions of the usual lanterns and dioptric apparatus of lighthouses not permitting us to use gas lights of a larger size than that which I have just described, and of which I have shown you a full-sized drawing, it seemed desirable to consider whether we could not usefully add still greater intensity to our lighthouse gas flames than that obtainable from gas only. All our intense lights, such as the lime light, the electric light, magnesium light, &c., are costly; but it occurred to me that if I could add some such intense light to my large gas burners, so arranged that it need not be used except in thick weather, I would, at comparatively small expense, produce a fog light combining both quantity and great intensity. I made many experiments, and at length arranged for what I termed a core for my gas burners. Any of the intense lights I have mentioned might form this core. I first used, as the simplest and least expensive, a rich hydro-carbon flame intensified by oxygen, but I prefer the electric light because of its greater intensity and because of the facility with which, owing to the recent improvements in the Gramme magneto-electric machine, it can be applied. When the Jablochkoff electric candle, which is now so much used in Paris, has been so constructed that it may be burned without variation for many hours together, it may be very easily utilised for the core of which we have been speaking, but in the meantime the light from carbon points regulated by a Serrin lamp is quite available for that purpose. By a simple alteration in the arms which hold the carbons, and of the clockwork by which those arms are moved, we can bring the light into the precise focus of the gas-burner and apply it in a moment when occasion arises. By means of a gas-engine, which of course can be used at all gas stations, it can be applied in a moment. With respect to this light, I will ask you to remember that its application is simply intended to add intensity to a large fog-light, and that it is only designed to be used during fogs, so that no expense is incurred except while the fog lasts, and during that time (it appears to me that) *no* expense should be considered too great when the possibility of saving human life is taken into account. By the kindness of the Commissioners of Irish Lights, one of these combined lights will be fixed at Howth Bailey Lighthouse, and an opportunity will be afforded to the members of the British Association of judging of its effect in connection with the great quadriform light which, as I before mentioned, will also be placed in the experiment house at that station, and visible at Salthill. I have read the programme of this Association at Salthill by the light transmitted from this combined light at Howth Bailey Lighthouse about six miles distant, a test of the power of a lighthouse light more severe than has ever before been applied, so far as I am aware.

I will only add that what I have said in the early part of this paper respecting the useful effect of sudden flashes in catching the eye of the sailor by what may be termed a momentary thrill in fogs and haze peculiarly applies to this combined gas and electric light; this light when suddenly exhibited, produces an exceedingly striking effect, well calculated to arrest the attention of the mariner.

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NOTES.

SIMPLE ELECTRIC LIGHT.—Mr. G. M. Hopkins, in the *Scientific American*, describes a simple light, but we doubt if it will be found of any great value. From the side of a vulcanite standard is a metallic spring holding the negative carbon. On the top of the standard is a lever, one arm of which has a spring to hold the positive carbon; the other arm holds a weight to balance the carbon. The weight is adjustable, and the whole apparatus is so arranged that the positive carbon presses very lightly on the negative. Connecting the two carbons with "a battery of four or six Bunsen cells, a small but very brilliant light will be produced. As the points burn away the upper carbon moves downward of its own gravity. The contact of the points is regulated by the moveable weight." It seems to us that the weight would require such constant adjustment as would render the whole apparatus of little practical use. If the weight consisted of a sand glass, so made that the sand ran out weight for weight with the carbon burnt, the exact balance might be kept.

TROUVE'S ELECTRIC EXPLORER AND BULLET EXTRACTOR.—The famous probe used by Dr. Nélaton in locating the bullet which struck Garibaldi is already a matter of history. It will be remembered that it was terminated by a ball of porcelain, the rough surface of which was found blackened by the lead. The contrivance was ingenious; but M. Trouvé's electric explorer for wounds, which is shown by him in the French Exhibition, is far more generally useful. The moment the two insulated needles which are exposed at its extremity come into contact with the fragment of metal, the fact is indicated by the ringing of a bell. With a little practice, it is easy to distinguish between lead and any other metal, since a contact made with pressure is less readily broken by inclining the stylet in the case of a soft than in the case of a hard metal. Two forms of extractor accompany the electric explorer, one being a delicate double screw, and the other a pair of pincers, of scissors form, of which the two portions are insulated from each other, so that a circuit may be completed when the ball or metallic splinter is seized by the instrument.

THE REVERSAL BATTERY OF M. TROUVE.—Accompanying and used with the above instruments is a very neat form of battery, composed of an ebonite tube, with a lid and bottom, screwing off and on. The upper half of the tube is lined with plates of carbon, constituting the negative element; whilst the lid carries the zinc element, which extends half way down the tube. The exciting and depolarising compound is said to be *bisulphate* of mercury, but we have no doubt but that the *mercurous* sulphate would answer the required purpose much more perfectly. To bring the battery into action, it is simply reversed; when not required for use it is placed in its normal position, in which the electrolyte is not in contact with the zinc and carbon elements.

THE INVENTION OF THE TELEPHONE. — "The honour of having given the first idea of the telephone is now claimed for the Paris *L'Illustration*, which in 1854 published an article on 'Electrical Transmission of Speech,' by a M. Charles Bourseul, soldier in the African army, containing the following passage:—'Suppose one were to speak near a moveable metal plate, so flexible as not to lose any of the vibrations produced by the voice, and that this plate should alternately establish and interrupt communication with a battery, you might have at a distance another plate which would produce at the same time the same vibrations. An electric battery, two vibrating plates, and a metal thread would be sufficient.' We have already mentioned that it was in 1855 Professor Wheatstone's telephonic concert was given, and in 1861 that Professor Reis made the first telephone, which was constructed on a principle similar to that described by Bourseul, and used by Professor Graham Bell." It should be noticed in connection with this extract that the great beauty of the Bell telephone is that no battery is required. Reis used a battery. Bell uses none. The difference is so great that the one can hardly be compared with the other.

THE MICROPHONE OF M. G. TROUVE.—This form of microphone, which has the appearance of a small dark-lantern, is composed of two discs of carbon, forming the top and bottom of the apparatus, which are held together by a cylindrical casing, a rod of carbon, pointed at each end, being placed centrally so as to connect the discs. The casing, one portion of which is moveable on hinges, like the door of a lantern, constitutes a sounding board, which concentrates any vibration upon the central carbon. Hence the extraordinary sensitiveness of this form of the instrument. Suspended in the middle of a room, and connected with a telephone at a distance, it is said to reproduce perfectly, with the true *timbre* of the voice, words spoken at a distance of over 25 metres from the telephone. It can thus reveal all the secrets of a large apartment. When placed on a table, it is no longer so sensitive to atmospheric vibrations, but transmits, not only the ticking of a watch or the sound of a footstep, but also a rustling so slight as not to be directly audible. Insects may readily be imprisoned within this telephone, all their evolutions being distinctly heard; and a watch, enclosed within the apparatus, seems to be making terrific efforts to escape.

COBALT PLATING.—Gaiffe had his attention called to the beauty and durability of cobalt, when deposited by the galvanic battery, and endeavoured to utilise it as a substitute for iron and nickel, especially in electrotyping. It does not rust like iron, so that the surface can be easily preserved in good condition, and it is easily dissolved by weak acids, which do not attack the copper, whilst the nickel cannot be removed from a copper plate without injuring it. The beautiful whiteness of the cobalt makes it valuable for the decoration of other metals. He recommends a bath of a neutral solution of the double sulphate of cobalt and ammonia, which requires in its preparation about as much care as the nickel baths. The anode may be a leaf of platinum, or a plate of cast or forged cobalt. In order to obtain an adherent and white deposit, a current of about six units of electromotive force [Brit. Assoc.] should be employed at the beginning, and it should be reduced to about three units when the whole surface has become white. With a suitable intensity of current, the cobalt deposit is made nearly as rapidly as that of nickel. In four hours the coating may obtain the thickness of ·025mm. If a very regular deposit is desired, the piece which is to be plated should be attached to the rheophore of the pile before plunging it in the bath.—*Comptes Rendus.*

THE BIRKBECK INSTITUTION.—We have received the syllabus of a series of lectures to be delivered at this institution by Mr. W. J. Wilson, F.C.S., M.S.T.E. The course consists of two parts, elementary and advanced, and is very comprehensive. The subjects mentioned in the syllabus are Electricity, Magnetism, Light, Heat, and Sound. The lecturer will deal primarily with the requirements of the Science Department, but, if the syllabus is fully carried out, the instruction given will be far in advance of what the department requires. The portion of the syllabus treating of electrical and magnetical science consists of ten paragraphs, the last of which is as follows:—Electrical Measurements and Measur-

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ing Instruments: Further study of Ohm's Laws; Kohlrausch's Verification; Units of Electromotive Force; Resistance and Current; Measurement of Resistance; Rheostat; Rheochord; Wheatstone's Bridge; Resistance Coils and Boxes; Temperature and Resistance; Percentage Conductivity; Measurement of Cell Resistance; Comparison of Electromotive Forces; Measurement of Current; the Voltameter; Electro Chemical Equivalents; Galvanometers; Tangent and Sine Galvanometers; Differential Galvanometers; Astatic Needle; Mirror Galvanometers; Conditions of Maximum Sensibility of a Galvanometer; Shunts and Divided Circuits; Calibration of Galvanometer; Measurement of Capacity; Retardation in Submarine Cables; Cable Testing; Finding Faults in Cable, &c., &c. Altogether, some sixty lectures are to be given "and fully illustrated with experiments, apparatus, diagrams," &c.

The Canadian Pacific Railway.—The following remarks occur in a short article in the *Engineer*, calling attention to the contracts for this railway:—"The reports of the chief engineer explain fully the progress made in locating the line on the several sections; the work on the preliminary contracts entered into for the erection of the telegraph and clearing the line of standing timber, for a width of 132ft. in the wooded districts; also the contracts for construction on 225 miles of section number two. The amount of each contract, and the expenditure on each, will also be found in the chief engineer's reports. It is intended that the works under contract and the expenditures on account of them, shall be assumed by the parties contracting for the whole work or for any particular section in which these contracts are included, and that the money and the land bonuses shall cover the entire mileage. A schedule of all contracts for works and rails will be found in the report of the chief engineer. The telegraph line has been built over a distance of 1,000 miles, on sections two and three, and the necessary clearances of woodland therefor have been made. There is now telegraphic communication from the whole of Eastern Canada to a point west of Edmonton, while preliminary arrangements have been made by the contractor in British Columbia by which the completion of the telegraph can be secured at an early date. Profiles of the line from Lake Superior westward, to the Pacific Coast, are now on exhibition at Ottawa and in the London office of the Canadian Government. The statute of 1874, entitled "The Canadian Pacific Railway Act of 1874," provides how the railway is to be established, built, and worked, and sets forth the character of the subsidies authorised by Parliament. The following is a list of printed documents, which may be had or seen on application at the office of the Minister of Public Works at Ottawa, or at the Canadian Government-office, 31, Queen Victoria-street, E.C., London:—(1) The Canadian Pacific Railway Act of 1874. (2) Reports of the Chief Engineer, recently published. (3) Description of the country to be traversed, compiled from independent and official sources, and giving an account of the mineral and agricultural resources of the country. (4) A map showing the country through which the line is to be constructed. (5) The last report of the Surveyor-General of Dominion Lands. Separate tenders will be received for distinct sections as undermentioned, as well as for the whole. (1) The section from Fort William on Lake Superior to Selkirk in Manitoba, about 410 miles. The telegraph and railway work in progress to be assumed at cost. (2) The section from Selkirk to Yellow Head Pass, about 1,043 miles. The telegraph under construction to be assumed at cost. (3) The section from Yellow Head Pass to Burrard Inlet, about 493 miles. Telegraph contract and work to be handed over at cost. (4) The whole line from Fort William to Burrard Inlet, about 1,946 miles. All telegraph and railway work to be handed over and assumed at cost."

The Postal Telegraphs.—We suppose that Mr. Buckle would have proved, had he lived, that public criticism visited each Government department in strict order, and that in the course of a century or so the tides of criticism would wax and wane according to some well established law. Be that as it may, it seems to be the fate of the telegraph department to be subjected to pretty constant and severe criticism. No sooner has Sir J. Vogel mooted the question of cheaper telegrams than Mr. Ledger *(vide Times)* introduces another grievance, and other gentlemen write in the same strain. Mr. Ledger says:—"The Government purchased the lines belonging to the railway as well as to other companies, and it was stated that the public in country districts would be able to despatch messages from any railway station. This privilege was granted for some two or three years, but it was then suddenly stopped without any corresponding increase in the number of village telegraph offices. The result is that many persons who, like myself, reside within a mile of a railway station have had since this untoward alteration to send three or four or more miles to a telegraph office. It also follows that we very seldom use the telegraph at all, and that we discourage our friends from using it because of the high charge that we are now forced to pay for the delivery of messages." A second correspondent writes:—"I can most heartily endorse the remarks of Mr. Ledger with regard to the intolerable inconvenience caused by the Government prohibiting the public to use the railway telegraphs in country districts. I live within two miles of two railway stations, one of which, a junction, has considerable traffic with London and Suffolk, and has been hitherto allowed a telegraph office. The only way I could console myself for a single delivery of letters and the distance of five miles from the nearest postal town was the comfort of this telegraph office; and some time ago I had the name printed on my writing paper to avoid paying the 4*s.* 6*d.* porterage for telegrams sent to the town. I thus saved many pounds. But, alas! after sending several telegrams this summer from the Continent home, I heard that they cost the receivers 4*s.* 6*d.* each, because the Government had stopped the public from using this railway telegraph office. What is the reason for this unnecessary loss to the neighbourhood and to the revenues of the country?" Another correspondent says:—"The letter of your correspondent on Tuesday last, on the subject of postal telegraphs, will be endorsed by others living in rural districts; but, in pointing out one breach of the conditions under which the House of Commons, especially county members, were induced to agree to the purchase of the telegraphs, he has omitted another and more grievous cause of complaint. When the tax-payers of England were induced to buy the telegraphs it was not so much recommended as a commercial speculation as a great convenience; the telegraphs were to become the property of the nation, and to be administered in connexion with the Post Office for the benefit of the people generally; the connexions with the railway stations were not only for the most part to be maintained, but every money-order office was by Act of Parliament to be also a postal telegraph office for the convenience of rural and agricultural counties." The letter states, further, that the authorities admit the claim of the village to a wire, but allege that it cannot be constructed because of a Treasury Minute to the effect that the Post Office shall not undertake extensions unless likely to yield a revenue. Our American cousins manage better than this.

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ELECTRIC ILLUMINATION.

Cost and Practical Application.—III.

In considering the practical application of the electric light, and its employment in the place of gas, one or two conditions must be steadily borne in mind.

The light afforded by gas or oil lamps proceeds from a great number of points, the electric light from one, or at most very few. Calculations are frequently given to show that the electric light is vastly cheaper than gas, because an electric lamp giving out light, say equal to 500 gas-burners, costs for motive power, attendance, and carbons consumed, much less than the gas consumed in 500 gas burners. This is true, no doubt, but then it does not follow that the electric light is capable of taking the place of the 500 gas burners. Indeed, in the majority of cases the one cannot be substituted for the other. If the magneto-electric machine produced, instead of one light equal to 500 gas burners, 500 lights each equal to one gas burner, the comparison would be a fair one, but, as it does nothing of the sort, a comparison of relative cost is made between two things essentially different.

It is true that of late years gas jets have been grouped together in certain exceptional cases so as to produce the conditions in which a comparison with the electric light can be very properly made. We allude to the so-called sunburners used in very lofty rooms or halls, where all the light is concentrated at one point in the ceiling, and, as all the points on the floor are nearly at the same distance from the sunburner, a very equal illumination is obtained. In such a case it is, of course, indifferent whether a hundred lights are grouped together or one light equal to a hundred; but no one would dream of collecting all the gas lamps in a long street, and disposing them in one, or even two, or three sunburners. In lighting a street the illuminating power must be distributed over a number of equidistant points, and to effect this a subdivision of some kind of the electric light is necessary. This has been in some measure effected by the Jablochkoff candle; but, as we have already pointed out, the subdivision is not carried to a very great extent, and each lamp gives about as much light as 60 gas burners, reduced by the opal globes to about 45. Now, if one electric light of this sort was made to do duty for 45 street lamps, the illumination of the street would be most unequal and imperfect. To arrive at a practical lighting of the street, the electric lamps must not be at a very much greater distance from one another than the present gas lamps. In the Avenue de l'Opéra, in Paris, which is lighted by 32 electric lights, the average distance of one light from another is about 60 yards, and it is clear that this distance cannot be very much exceeded. The result is that the street is most brilliantly illuminated. It is the *beau ideal* of what street illumination should be; the tall houses are clearly visible from top to bottom, and at any point the most minute objects can be distinguished. The question is this—can this brilliant street lighting be attained at the same cost as the old murky street lamps, or, if not, is the cost commensurate with the increased advantage? It would be much more expensive to light up with gas the Avenue de l'Opéra as brilliantly as it is now lighted with electricity; but it is impossible to light with electricity—say, for instance, Regent-street as badly as it is now lighted with gas. Comparing the total amount of light, electricity is cheaper than gas; but, in the present state of knowledge, if we adopt electricity, we must make up our minds to a much more brilliant illumination, cost what it may.

Bearing these considerations in mind, let us examine the actual cost of the electric light, which consists of four elements:— 1. Mechanical energy absorbed. 2. Cost of carbons consumed. 3. Interest of capital, and wear and tear. 4. Wages of attendants.

The following table gives approximately the amount of light developed by the various kinds of machines for one-horse power absorbed:—

Maker.	Revolutions per minute.	Spermacceti Candles.	Gas Lights in 16 Candles each.
Gramme, 1877, continuous currents	850	2560	160
Lontin	300	2500	156
Siemens, Small No. 68	850	2080	130
„ „ „ 58	850	1582	99
Alliance	400	543	34
Holmes	400	476	30
Gramme alternating currents, and one Jablochkoff candle	600	1000	62
De Meriten's 3 Jablochkoff candles	700	3000	187

This last is given on the authority of Du Moncel, and seems a most extraordinary performance. We may mention that the light afforded by the Jablochkoff candle is stated by the company to be equal to 100 carcel lamps, of eight French standard candles = 10 English standard spermacceti candles each lamp, but we doubt very much whether this amount of light is obtained in actual practice.

In estimating the cost of the electric light, it will be sufficient to take as examples that afforded by the Gramme machine of 1877 for continuous currents, and the Jablochkoff candle, worked with the Gramme machine, for alternating currents. Too little is yet known of De Meriten's machine to warrant its being brought into the calculation.

The cost will vary very much with the number of hours per annum that the light is kept in action, as the interest of money on the original outlay plays an important part in the actual daily cost. As the electric light produced by the continuous current, with the aid of regulators, has hitherto been used chiefly for lighting large factories, we will take three possible cases:—1. In which the apparatus is used five hours a day on the 100 short winter days; 2. In which it is used all night, say 300 days of ten hours each on the average; 3. In which it is also employed for 300 days of ten hours each, but in a factory where there is power to spare, and the motive force required to drive the machine costs practically nothing.

The Gramme machine, with its regulator and accessories, costs about 100*l*., and the two-and-a-half or three-horse power engine and boiler required to drive it about 150*l*., say 250*l*. in all.

1. 100 days of 5 hours each:—

		£	s.	d.
10 per cent. interest on capital		£25	0	0
1½ tons coal	@ 25*s*.	1	17	6
40 yards carbons	@ 1*s*. 8*d*.	3	6	8
Stoker	per hour, 6*d*.	12	10	0
Or, 1*s*. 8½*d*. per hour		£42	14	2

2. 300 days of 10 hours each:—

		£	s.	d.
10 per cent. interest on capital		£25	0	0
9 tons coal	@ 25*s*.	11	5	0
240 yards carbons	@ 1*s*. 8*d*.	20	0	0
Stoker	per hour, 6d.	75	0	0
Or, 10*d*. an hour		£131	5	0

3. 300 days of 10 hours each, motive power costing nothing:—

		£	s.	d.
10 per cent. interest on machine, only £100		10	0	0
240 yards carbons	@ 1*s*. 8*d*.	20	0	0
Or, 2½*d*. per hour		£30	0	0

for a light equal to 160 gas lamps of 16 candles each.

The Jablochkoff candle is chiefly employed for lighting streets, and in Paris it is not used all night. After midnight, the feebler and cheaper illumination of the gas lamps is considered sufficient; but, as it is not so much a question of employing electricity and gas together as of comparing the advantages and relative cost of the two systems, we will assume a minimum of 4,000 hours per annum.

The cost of a Gramme machine for alternating currents capable of producing 16 lights is	£400
That of a sixteen-horse engine and boiler, say	500
Add for connections, and accessories, say	100
	£1,000

A Jablochkoff candle burns an hour and a half, but, as some will not be completely burnt out, let us say 3,000 candles are required for each light per annum.

16 Jablochkoff candles 4,000 hours per annum:—

Interest on capital at 10 per cent.		£100
48,000 Jablochkoff candles	@ 7½*d*.	1,500
Coal, 200 tons	@ 20*s*.	200
Stoker per annum		70
Day inspector cleaning lamps, and placing candles		65
Night inspector attending to commutators		65
		£1,990

or say 10*s*. per hour for 16 lights.

Or 7½*d*. an hour for a light equal to 1,000 candles, or 62 gas lights of 16 candles each.

When gas costs 3*s*. 6*d*. per 1,000 feet, and gas lights burn 5 cubic feet per hour, the cost of each light is $\frac{17}{25}$ farthing per hour, which, multiplied by 62, gives 14 pence as the cost of producing by gas the same amount of light as is emitted by the Jablochkoff candle.

In comparing the relative cost of the absolute amount of light produced by the three systems reduced to a light equal to 160 gas lamps, we obtain

		s.	d.	
Continuous currents and regulators	1 ...	1	8½	per hour
„ „ „	2 ...	0	10	„
„ „ „	3 ...	0	2½	„
Jablochkoff candles		1	[illegible]	„
Gas		3	0	„

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Looking at these figures, it is clear that, in factories where motive power is available, there is an enormous economy in the use of the Gramme machine, with regulators, particularly if the workshops are lofty, so as to distribute the light equally over the working space. In many cases it is an advantage, considering the large amount of light available, to cause the whole of the light to be directed on to a white ceiling, and thus only indirectly to light the workshop, by which device the light is remarkably diffused and all shadows are avoided.

When a boiler and engine unused for any other purpose has to be put up, the advantage is less considerable, but in all cases the more hours per annum the apparatus is worked the greater is the economy.

It must moreover be borne in mind that, although we have charged interest on capital for the apparatus required for the electric light, we have not made a similar charge for the gas fittings, which are difficult to estimate, and this omission must go to the credit of the electric light. In the case of the Jablochkoff candle for street illumination, although the total amount of light produced is cheaper than an equal amount produced by gas, it by no means follows that street illumination by this novel system is more economical. For reasons we have mentioned at the commencement of this article, it is impossible to replace sixty-two gas lamps by one Jablockhoff candle. At the very outside, one Jablockhoff light cannot be substituted for more than two gas lights, as they are at present arranged in the London streets, without making the lighting of the streets excessively irregular. The two gas lights cost 1 14-20th farthing per hour; the Jablockhoff candle, 7½d.; that is to say, nearly twenty times as much. The difference is enormous, and few lighting boards would like to face the expense. On the other hand, there is no comparison between the two illuminations. A street lighted with electricity is really lighted; a street, lighted as streets now are with gas, is little more than darkness visible. Though we cannot suggest that electric street illumination is sufficiently advanced to warrant its general adoption, we think it might be advantageously applied to such streets as Regent-street, Oxford-street, and Piccadilly, which are wide streets, more or less handsome, and with a good deal of traffic.

On looking at the calculation it will be evident at once that the main item of expense is the Jablochkoff candle itself. The price demanded by the patentees, 7½d. per candle, is very high, and quite out of proportion to its real cost. There is no doubt at all that they could be sold for half the price, and still leave a good profit. If the patentees wish the system to become at all general, they will do well to be more moderate in their terms.

The Jablochkoff company pretend that they can work through circuits of very considerable length, but, as a matter of fact, they do not attempt to do it. The Avenue de l'Opéra, which has a length of about 1,000 yards, and is lighted with thirty-two lights, is not lighted from one, but from two electric stations, so disposed that the wires going to the lamp-posts shall be as short as possible, notwithstanding the obvious economy of having all the motive power and electrical apparatus in one place. As the best results are always obtained when the internal and external resistances are equal, that is to say, when the resistance of the lights and conductors is equal to that of the generating bobbins, it is clear that an increased length of wire must give an inferior result, or that fewer lights can be employed in the same circuit, so as to compensate the increased resistance of the conductors.

The domestic use of the electric light is, in the present state of our knowledge, not in question at all. The light is far too glaring and expensive for small rooms, and, until some means can be found of subdividing the electric light to a much greater extent than has been done hitherto, it is useless to think of its employment except in very large spaces. Lontin and others claim to have subdivided the electric light, because a number of lamps can be kept going with one machine. A very powerful light can be obtained from 120 cells of Bunsen's battery. Four lights of much inferior brilliancy can be obtained by dividing the battery into four smaller batteries of 30 cells each, but this is a sub-division of the battery and not of the light. This is what Lontin does; he subdivides his machine, and the same thing can be done with Gramme's alternating current machine, with the Alliance machine, and indeed any machine in which the inducing currents and induced bobbins are numerous. This is not, however, a subdivision of the current so as to make it work simultaneously several lights each of small intensity.

The gas companies have little to fear at present from electrical competition. Although the electric light is certainly cheaper in some cases, and affords an amount of pure white light which it is out of the power of gas to produce, the cases in which the new light can be applied with advantage are as yet only exceptional. There is a second use for gas, which has been of late years enormously developed, which will for a long time enable it to hold its own, we mean as an article of domestic fuel. It is becoming so thoroughly established in this respect that every house must have its gas supply on this account alone, and the gas once in the house it will be used for lighting as well. There is a great advantage possessed by gas, which is up to the present time entirely wanting in the electric light. It can be regulated with the greatest nicety and by the simplest means. It can be turned down to the blue, or turned up to its full power in an instant. The cost of the electric light will, no doubt, be diminished very much in the next few years. The machines are at present very dear, quite out of proportion to their cost. Fortunately, the magneto-electric machine is not a monopoly. There are several systems nearly equally good, and although all are patented, they must necessarily come into competition with each other. Other and probably improved constructions will be brought forward from time to time, so that the original outlay involved in the purchase of a machine will soon be a comparatively small matter. Probably, the Jablochkoff candle will be reduced in price before long, otherwise it will be cheaper in the majority of cases to use regulators.

The cases in which the electric light can be most usefully employed are:—Lighthouses, for which its properties more eminently fit it. It is a brilliant point of light, which can be better dealt with, both catoptrically and dioptrically, than any other known source of light, but for this purpose the Jablochkoff candle is useless, as it burns down gradually, and on this account the point of light would always be getting out of focus. Besides, the regulators give much more light for the same amount of mechanical force absorbed.

In all cases where sun burners are employed the electric light may be substituted with advantage, supposing conveniences are at hand for generating the electricity, but it is better to allow the light to enter the room through a screen of ground glass in the ceiling. For lighting factories where mechanical power can be had for nothing, the light is eminently suited, and the same thing may be said of its use on board steam vessels, where the generation of the electricity would not cost anything at all. For both these purposes the regulators are to be recommended. For lighting up large retail shops and warehouses, the Jablochkoff candle has been somewhat extensively used in Paris, and possesses some advantages over the regulators on account of the greater number of points from which the light proceeds. For street illumination the Jablochkoff candle is to be preferred, but, so far, its use is only possible when the beauty of the illumination is considered to compensate the far greater cost.

ON THE STUDY OF ELECTRICITY AS A PROFESSIONAL PURSUIT.

BY THOMAS T. P. BRUCE WARREN.

[CONTINUED FROM P. 200.]

A Bunsen's burner should be used, with a rose and a hole at the top, which can be open or closed, so as to use the gas as circular jets, or as one flame which can be directed on to the crucible with or without the blower, as may be required. The distance the burner should be placed below the crucible should be such that when the hole in the rose is opened the flame will well reach the lower part of the crucible, so that, when the blower is used, the portion of the crucible, as far up as the contents reach, can be made intensely *red* hot; a white heat, whilst the hydrogen is passing, will reduce zinc sulphide easily, and the metal being volatile readily escapes. Cupric sulphide parts with a portion of its sulphur, but the metal not being volatilised the loss is not likely to be so great.

With zinc sulphide the blast may be used for two or three minutes; five minutes will lead to a loss of one or two per cent. Cupric sulphide may be heated for three or four minutes.

The preliminary heating should be such that the heat a few inches above the crucible cannot be borne by the hand; the contents of the crucible will then be heated to about 400°F. The gas is passed slowly, until the vapours cease to be visible from the crucible. This may be kept up for ten minutes. The gas is now passed more rapidly, and the flame from the top of the burner used for a minute or two without the blower. The blast is then used for two minutes, and the flame allowed to play on the crucible until all incandescence is over, when the gas is passed more slowly. The lamp is removed, and the whole allowed to cool in a gentle current of hydrogen. This is to prevent access of air, which by oxidising the sulphides would lead to inaccurate results.

A is the apparatus for generating the hydrogen, the zinc being placed in the central bulb. B is a two-necked Woulfe's bottle containing water for washing the gas. C is a chloride of calcium tube for drying the gas before passing to the crucible D. E is a

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Bunsen's burner with tube F for connecting to the blower. G is connected to a gas tap.

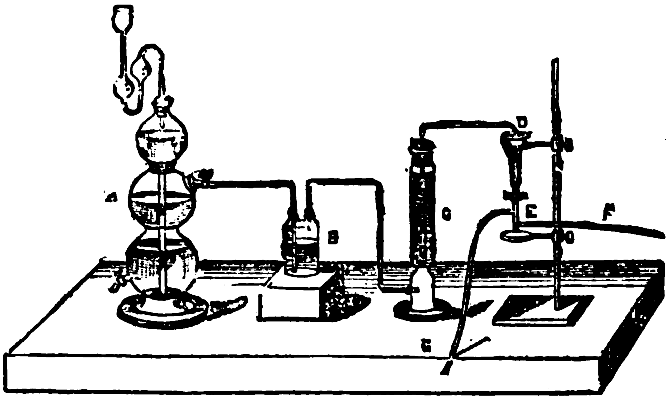
By means of the stop-cock in A the flow of hydrogen can be easily controlled.

No laboratory can be complete without this apparatus in its most perfect arrangement. The estimation of those metals whose sulphides can be treated in this way is one of the most important achievements in analytical research. The fact, too, that many salts, including sulphates of zinc and copper, can be converted into sulphides, and the amount of metal estimated with such little trouble, ought to render this apparatus almost as indispensable to the electrician as a galvanometer.

Reference to this apparatus will be necessary when treating of spelter and sulphate of zinc.

It is not my intention to deal so fully with the other chemical substances employed by the electrician as I have with copper and its sulphate. I shall give the methods by which ordinary impurities may be easily detected in some of the more important substances; and, in order that the student may better understand the nature and effects of the impurities likely to be met with in the commercial article, I would recommend him to purchase a supply of the pure article, and satisfy himself first of its behaviour. In this way he will have a much clearer idea of what he is about. He may then add one ingredient at a time, in some fixed quantity, and so proceed, until he has built up the more or less complex representative of the commercial substance. He then knows not only what to look for, but he has a knowledge of the quantities put together, and has consequently something to act upon as a test for his capabilities towards exactness.

Mercury and its Salts.—Mercury is employed in its simple form as a metal for one of the elements in a battery, and for amalgamating zinc. Mercury cups are used for connecting different parts of a circuit. Mixed with other metals, as tin, zinc, and lead, it is used for electrifying machines. It was proposed by Siemens for the production of a standard of electrical resistance.



When pure, a globule of it, if allowed to fall on a piece of paper and made to run about, does not elongate or tail, nor does it make any streak. It disappears entirely when strongly heated. If tin, lead, or zinc be present, the globule will not remain spherical when made to move about, but will form a kind of tail, and also give a stain to the paper. If shaken in a stoppered bottle for a short time, a portion of the impurities will be oxidized and float on the surface. When heated the mercury will disappear, leaving the impurities as oxides. A very strong heat will drive off a portion of the lead as oxide, and also the zinc in its metallic state. A large portion of these impurities may be removed by digesting with nitric acid. After the removal of the nitrates by washing, &c., the tin may be taken up by digesting with hydrochloric acid; the mercury when well washed with distilled water will be found sufficiently pure without distilling. To obtain the metal perfectly pure it must, after this digestion, and when well washed, be distilled.

The pure metal should leave no residuum when heated strongly; when once distilled only, it may leave a little residuum as silica, oxide of tin, &c. Two distillations with digestion in nitric acid will yield this metal almost absolutely pure.

When mercury has been used in mercury cups for a little time its surface becomes coated with oxide and dust; it can be easily separated from these by squeezing through a piece of chamois leather. The terminals which are placed in the mercury are usually tinned; it would be far better to use bright copper, or, if it is necessary to guard against tarnishing, to coat them with platinum.

Sulphate of Mercury.—The protosulphate or mercurous sulphate is used in the Marie Davy Battery, and for Clark's standard element. For this latter purpose it must be free from the acid salt, or persulphate, called also mercuric sulphate. If pure mercury and pure sulphuric acid be employed in the manufacture of this salt, the only impurities likely to be met with are the mercuric sulphate.

Good results have been obtained in constructing a constant battery with this salt. It is not, however, a salt which from purely chemical reasoning, would appear best suited for this purpose. The Marie Davy battery was, before the introduction of Leclanché's element, the most lasting battery in use, and I fancy the introduction of this salt into Clark's element probably arose from this fact. The commercial salt when well washed with distilled water should be preserved in a closely stoppered bottle, in a dark place.

Sulphate of Zinc.—There are two descriptions of this salt met with in commerce, the common white vitriol, as it is called, and the pure sulphate.

Sulphate of zinc, when pure, should be entirely soluble in water. Ammonia added produces a precipitate which is redissolved on the addition of an excess without any coloration.

Its solution, slightly acidified with acetic acid, should be entirely precipitated with sulphuretted hydrogen. A residuum on evaporation would probably be due to iron.

If copper be present its ammoniacal solution will be more or less blue.

The pure salt is represented by the formula $Zn'' SO_4 7H_2O$. The amount of zinc in the pure salt may be at once estimated by first carefully drying the powdered salt, and heating in a crucible with a little flower of sulphur, in the manner given for estimating copper from its sulphide.

One gramme of the salt should yield ·35 gramme of the sulphide.

The amount of zinc sulphate in the commercial sulphate known as white vitriol may be determined by dissolving the salt in water and filtering; the insoluble portion should consist of zinc sulphide from the imperfect roasting of the ore; ammonia in excess is added to the filtrate, and allowed to stand in a warm place until all the iron has become peroxidised; it may be necessary to boil the filtrate, before adding ammonia, with a small quantity of nitric acid to peroxidise the iron.

The ammoniacal solution is filtered and hydrosulphuret of ammonia poured in until the superabundant liquid has a decidedly yellow colour. By standing for about twenty-four hours in a warm place, the zinc sulphide subsides and may be filtered off, the washing being performed with water containing a little of the hydrosulphuret ammonia, so as to prevent the oxidation of the precipitate, which would cause the sulphide to be converted into sulphate, and so pass into the filtrate.

The precipitate, when dry, is heated with the filter ash in Rose's crucible, with a little sulphur.

The liquid filtered from the sulphide should, on evaporation and ignition, leave no residuum. Magnesia may be found as an impurity.

If this is suspected to be present, solution of chloride of ammonium should be poured in before adding the solution of ammonia; in any case, its addition produces no impediment to the subsequent part of the process.

Arsenic, if present, would be dissolved in the excess of hydrosulphuret of ammonia.

Oxide of Zinc should be entirely soluble in dilute sulphuric acid, without effervescence. The solution, neutralised with ammonia, and the same added in excess, and allowed to stand in a warm place for a few hours, will deposit the iron, if present, as hydrated peroxide. Hydrosulphuret of ammonia, added to the filtrate as above, will precipitate the zinc as sulphide, which should be tested in a Rose's crucible. One gramme zinc oxide = 1·19 gramme zinc sulphide.

Zinc.—The amount of zinc contained in a sample of spelter may be determined in the same way. The lead will be converted into sulphate, which may be filtered off; silica, sulphur, and copper, if present, will also remain as insoluble matter. The solution rendered strongly ammoniacal, and digested in a warm place, will deposit the iron. Hydrosulphuret of ammonia added to the filtrate will precipitate the zinc, which should be estimated as sulphide.

Spelter of good quality contains from 1·5 per cent. to 2·3 per cent. impurities, of which lead, sulphur, and silica may amount to 1·3 per cent. or 2·0 per cent., the remainder consisting of iron, arsenic, copper, oxygen, cadmium, fluorine, &c.

The separation of zinc from copper, as in examining battery residues, will be treated in a future paper.

[TO BE CONTINUED.]

Lamplighting by electricity has now been in practical operation in Pall-mall for the last fortnight. All the lamps comprised in the circuit are put out or lighted at the same moment. This, of course, does away with the lamplighter's occupation.

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THE ELECTRICIAN.

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We cannot undertake to return drawings or manuscripts, and must, therefore, request Correspondents to keep copies.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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NOTICE TO EDITORS.

We shall be happy to exchange with the Editors of Scientific journals who receive the first numbers of THE ELECTRICIAN.

Nous serons heureux de faire l'échange avec Messieurs les Rédacteurs des Journaux scientifiques qui recevront les premiers numéros de L'ELECTRICIAN.

Es wird uns ein Vergnügen sein mit den löblichen Redactionen der deutschen und anderen continentalen Journäle und Zeitschriften, denen die ersten Nos. des ELECTRICIAN *zu Händen kommen möchten auszutauschen.*

I Signori Editori di giornali scientifici che riceveranno i primi numeri dell' ELECTRICIAN *ci faranno cosa gradita accettando il cambio che loro offriamo.*

TELEGRAPHIC EDUCATION.

In a recent article, the suggestion was made by us that the Society of Telegraph Engineers should concern itself more directly with the elementary technical education of students of electricity. At the same time, we stated that we could give no encouraging answer to a transatlantic correspondent inquiring what means of instruction are offered in this country to a telegraphist who wishes to make himself master of his art. What he requires, we said, is only to be had from private schools or teachers at considerable expense, or in the office of a company where the training cannot but be hasty and empirical. Now, it has been pointed out to us that (as we were previously aware,) there is in London a school of telegraphy from which the ranks of the rising generation of telegraphists and electricians are largely recruited, and which has, probably, done more than any other institution to combine a thorough practical training with sound theoretical instruction in the education of telegraphists. And complaint is made of scant recognition on our part of an establishment which dates from 1868, and which, since that period, had, with constantly-increasing efficiency, done a vast amount of unostentatious work in the direction of telegraphic education.

We should be very sorry that any observations of ours should be taken in a sense which might imply a want of just appreciation, or a tendency to ignore the claims of any workers in the same field as ourselves. It should at once be stated that our above-mentioned correspondent appeared to us to belong to a class which in telegraphy has given some splendid examples of hard-earned success—the class of those whose energy and desire of self-improvement is in excess of their means of obtaining the educational advantages which are open to others. We must confess that our observations applied almost exclusively to those of whom Horace says:—

> Haud facile emergunt quorum virtutibus obstat
> Res angusta domi.

And few will deny, we think, that the meagre educational facilities afforded to this class of workers might, with benefit to the profession, be extended in the direction we have indicated.

On the other hand, it may justly be pointed out that telegraphy is now a profession which, like other professions, may reasonably expect from its votaries not only an elementary education of a preparatory character, but also a special training—not erratic and empirical—but of a definite technical nature. Considering the matter from the point of view of demand and supply, we might, perhaps, reasonably expect such training, when efficient, to be at least as expensive as that of any other profession affording the same opportunities of advancement. The demand should be, in fact, considerably in excess of the supply, for there are very few directions in which the requisite training, embracing much knowledge which is accessible only with difficulty and under peculiar conditions, can be obtained. Nevertheless, it is claimed, and we think with some reason, that there is no profession in which, having due regard to present and prospective advantages, the requisite training can be obtained more inexpensively than in that of telegraphy.

That present and prospective advantages are to be found in this profession—more particularly in the direction of submarine telegraphy—will scarcely be denied by those who are aware of the keen competition and overcrowding which exist in almost all the professions, and who have duly considered the probability that the applications of electricity will become vastly extended. Considering that a well-instructed telegraphist should be able to turn his hand, if necessary, to any application of electricity which may become commercially developed and grow into importance, it is not too much to say that young men who have the time and the means to devote to a professional training, but whose time and means require to be utilised to the utmost, could scarcely at the present time do better than to undergo a course of practical and theoretical instruction, followed by an examination, in a good school of telegraphy.

Let us glance at the requirements of such a school. In the first place, all the signalling instruments in ordinary use, such as the single-needle, the Morse recorder, and Wheatstone's automatic recorder, require to be represented, duly arranged in circuit, and to be taught by a preceptor who, in addition to manipulative skill, has the more rare talent of communicating to others his own knowledge, together with labour-saving method and a good "style." Then, in the more advanced manipulation class, the learner has to make the acquaintance of the "mirror receiver" and "syphon recorder." But, in order that his experience of these instruments should be of any real utility, he must work with them under the conditions of practice, that is to say, they must be circuited on a cable, real or "artificial." A real cable being obviously out of the question, a very expensive piece of apparatus, an artificial cable, such as those devised by Mr. C. F. Varley and by Dr. Muirhead, becomes of absolute necessity. These, as most of our readers are aware, are composed of condensers, or "inductive resistances," alternating with, or constituting at the same time, conductive resistance; the combination of the two producing the retardation of signals observable upon long submarine lines. We fear that such a piece of apparatus is of rare occurrence; yet it is a *sine quâ non* for an efficient school of telegraphy, being requisite in order to acquire a knowledge not only of the operations of submarine signalling, but also of those of testing cables. The technical acquirements required in teaching the latter, with their modern refinements and improvements, are of a somewhat high order; and the same observation applies in greater degree to the

acquirements requisite for the theoretical course of instruction, in which the learner should be well grounded in certain branches, at least, of physics, chemistry, and mathematics, as well as in electrical applications generally. Here the antiquated electrical science of the less recent text books would be of very little avail. What the student requires are the most modern views, together with the earliest information of those discoveries and novel methods which form part of the theory of to-day and may be built into the practice of to-morrow. For this course of instruction in the theory of electricity very delicate instruments, besides others of a rougher character, are absolutely requisite; and, what is of yet greater importance, the skill to use such instruments, the faculty of giving demonstrations which from their neatness and certainty are calculated to encourage the student in the use of methods of precision, should also be forthcoming.

Any establishment devoted to telegraphic education, and possessing all these requirements, may count upon our support, whenever this may be invited by an appeal to our judgment in accordance with evidence laid before us. And, we may add, it would, in our estimation, have everything to gain by courting publicity in the scientific Press. Understanding, as we do, that perfection is attainable only by degrees, our criticism would not be unnecessarily severe even if defects could be pointed out in relation to certain of the requirements in question. But hitherto, as we are under the necessity of pointing out, there has been, so far as we are aware, no description of the *matériel* and methods of any School of Telegraphy in any journal devoted to electrical or engineering science.

In conclusion, we would suggest that such an educational establishment might, probably with advantage to all concerned, be modified and extended, in a liberal spirit, so as to meet to a considerable extent the requirements of every class of student. In this country, the initiative in matters having an important practical bearing is so generally taken by private enterprise that it would be by no means contrary to our traditions if a really national School of Telegraphy were to originate from the same prolific source.

SINGLE AND DOUBLE CURRENT DUPLEX-TRANSLATION.

BY PROFESSOR W. E. AYRTON.

In any system of translation the two following conditions are essential, in order that the connections at the intermediate station may be rapidly changed from direct speaking to translation without the necessity of adjusting any relay either at the intermediate or terminal stations:—

1. The current received on each line, say the up line, at the translating station should work the same relay whether the station be merely receiving or translating.
2. The current sent forward on either line, say the down line, from the translating st..tion should come from the same battery whether that station be speaking or translating.

At the present time duplex working is becoming so extensively employed that it is desirable to consider how these conditions can be best fulfilled compatibly with the arrangements necessary for duplex working. In duplex working it is necessary:—

1. That t..e current leaving a station shall not affect the relay of that station,
2. That the motion of the sending key, whether this be a hand or an automatic key, should not alter the *total* resistance of the home receiving apparatus, otherwise the balance at the distant station will be interfered with, causing bad signals should that station be also sending.

The arrangements shown in figures 1 and 2 for single and double current duplex-translation respectively fulfil, each of them, the above four conditions.

For speaking, the plugs are put in S and *s*, for translation in T and *t*, A and B are the relay and local instrument (Morse or polarised receiver, &c.) for the up line, *a* and *b* for the down line; the armatures of the local instruments play up and down between two insulated springs, as in Siemens' translating Morse instruments, but the instruments shown in the figure have this peculiarity, that the upper springs C and *c* continue to press on the armatures in their downward course until they reach the lower springs D and *d*. *The object is to enable each amateur to act like a Sturm's key in order to fulfil duplex condition No. 2, quoted above.*

To trace the course of the current, let it come from the terminal station along the up line; it passes round the up line relay A, then through plug T, to the armature of the local instrument *k*, and thence to spring *c* and to earth. The tongue of the relay A is attracted and the local circuit of B closed; this brings the pole of the down line to battery *e*, which is joined to spring D, in contact with the armature of the local instrument B, thus sending a current through *t*, in opposite directions, round the differential relay *a*, and, therefore, not affecting it; one portion, however, of the current proceeding on along the down line to the terminal station, producing the signal there. If the down terminal station be also sending, then the armature of the down line local instrument *b* at the translating station will also be attracted, and a current will be sent from the up line battery E both ways round the differential relay A, and a portion will proceed along the up line to the terminal station, producing a signal there.

FIG. 1

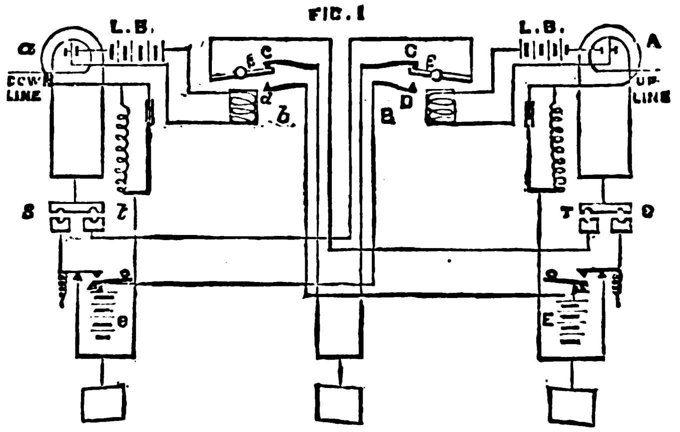
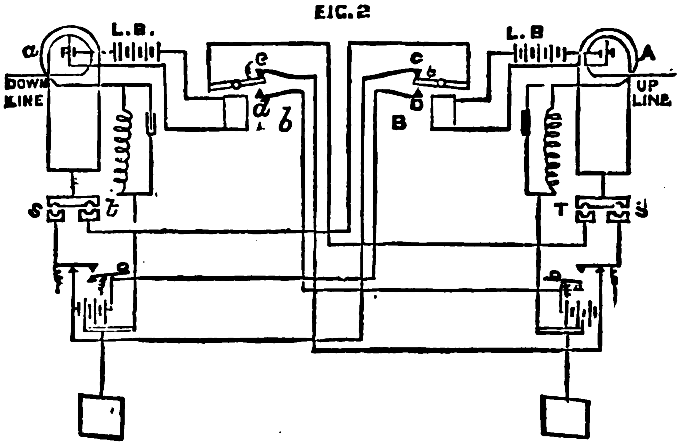


FIG. 2



For simplicity of explanation, I have used the current proceeding in different directions at the same time along a wire, and spoken of their separate actions; in reality, of course, it is the difference current which has to be considered.

In Figure 2, for double current duplex translation, the arrangements are the same, with the exception that the centres of the line batteries are to earth, and the connections so made that when no signals are being sent and both the armatures of the local instruments at the translating station are in contact with the upper springs, negative currents are sent in both directions to hold back the tongues of the terminal relays.

The Scientific Club, Savile Row.

THE PARIS EXHIBITION.—III.

Besides the experiments with the secondary battery, mentioned in our last, we saw a new modification of the Leclanché battery, in which a solution of chloride of lime is used as the exciting agent; also, Gramme machines, in various stages of manufac-

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ture. M. Niaudet, also, shows us a plan he has adopted for cutting the zincs of batteries. As every one knows who has had the least experience with batteries, the soldered joint frequently causes trouble. A cylinder of zinc long enough to make the zincs for two cells is taken and so cut that the operative is able to obtain two complete zinc elements, each having a good contact piece, without the use of solder. Returning to the exhibit in the French Annexe, those interested in telephony will notice the neat arrangement of the apparatus required in telephonic telegraphy. Really, electrical instruments will soon be looked upon as adding to the ornamental as well as the useful. MM. Breguet arrange a call bell and a couple of telephones upon a vertical mahogany board. The telephones have rests upon which to be placed when not in use, and by means of a plug they can be put in or taken out of the circuit.

M. Frion, of 6, Rue de Bourgogne, shows a large assortment of porous jars, one of which is evidently intended to show how far the manufacture of good ware can be carried, for it is one metre in height and has the same circumference. It is hardly possible to expect any of our enterprising friends and experimentalists to dabble with many batteries requiring porous jars of this size.

M. A. E. Chambner shows a specimen of his printing instruments, and next to this stall is that of M. d'Arlingcourt, who has one of the most interesting exhibits in the room, the autographic telegraph. We cannot do better than to incorporate here with our own observations some of those made by M. Halley d'Arros in a recent number of *l'Electricité*. Most of our readers are acquainted with Caselli's system, and M. d'Arlingcourt's seems founded upon that. M. d'Arlingcourt uses two cylinders upon which strips of paper 11½in. by 2¾in. can accurately be fixed. One of these strips consists of metallic foil paper, the foil being, of course, a good conductor. The second slip is a piece of chemically-prepared paper, *i.e*, paper prepared with ferrocyanide of potassium. In contact with each cylinder, or rather with the paper upon each cylinder is a platinum point; these points are also connected with the line wire and to the battery. The circuits are so arranged that the current from the battery can either be sent into the line or short circuited. By means of clock-work arrangements the cylinders at both ends of the line are made to revolve synchronously, so that the platinum points are passing over the same part of the corresponding surfaces at the same time. The message, plan, or map, forming the despatch, is written with a greasy kind of ink upon the foil paper. The cylinders are set revolving, and by a lateral motion the style is able to pass over the whole surface of the foil. As long as it is in contact with the foil the current is short circuited, but, whenever it comes into contact with the ink of the despatch, the current passes into the line wire, and hence to the receiving cylinder, the ink being a bad conductor. A blue mark is made upon the chemically prepared paper, and the total of these marks represent exactly the original despatch. M. d'Arros points out the great use of this instrument for military purposes. Nowadays an army in position occupies an immense space, and we may say that the tendency is to increase the space occupied, as close formation would be suicidal in these times of breech-loaders and such like arms of precision. It is, therefore, difficult for the commander to correspond, without great loss of time, by the old method of aides-de-camps and horses, and thus electricity is brought into service. The simplification of telegraphic instruments, again, does much to facilitate the use of electricity in war. The Military Commission on Telegraphy in France, hearing of M. d'Arlingcourt's work, decided to try it, although the inventor was very ill, and wished to be a witness of the trial. In order to overcome this difficulty the sick room was put into connection with the camp of Saint Maur by means of the underground wires of Paris. Notwithstanding the intense induction currents encountered, the experiments were completely successful.

CORRESPONDENCE.

BRITISH ASSOCIATION UNITS OF MEASUREMENT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Below is a table of Electrical Units, as used in my class for several years past. The units numbered 1, 4, 5, and 6 are those published by Mr. C. F. Varley on behalf of the Committee on Electrical Standards. No. 7 is the British Association unit of Work, which I have constantly had occasion to use, and which I have ventured to name after the distinguished physicist, Dr. Joule, who has recently passed away from amongst us. In regard to No. 2, named after Franklin, a few words of explanation are necessary.

This unit is the analogue of the Ohm, and the reciprocal of the Farad. This latter unit, which has for its analogue in dynamical electricity a unit of *conductivity*, was proposed and adopted with an inconsistency which appears to me to be due simply to the fact that the complete analogy which exists between the conductive and the inductive circuits has been but imperfectly recognised. If in dynamical electricity a unit of resistance is made use of in preference to its reciprocal, the unit of conductivity, then a unit of resistance should be employed in electrostatics in preference to a unit of capacity.

The two branches of electrical science are, in fact, not completely different, as they have been represented, but are closely parallel; and the laws and formulæ which apply to inductive resistance are virtually the same as apply to conductive resistance.

To give an example:—Let ϕ be the "constant" for microveber current of a given galvanometer, n the multiplying power of its shunt, and D the deflection obtained upon it, through the unknown resistance R, under the electromotive force E. Then

$$R = \frac{\phi\, E}{n\, D} \text{ megohms.}$$

Now let $D_{\prime}$ be the "throw" obtained on charging or discharging, through the same galvanometer, a condenser having the unknown *inductive resistance* R^i, and let t be the time in seconds occupied by half a complete vibration of the galvanometer needle under normal conditions. Then

$$R^i = \frac{\phi .\ E.}{\cdot 3183\ n\ D_{\prime}\, t} \text{ megafranks.*}$$

The electrostatic capacity will, of course, be the reciprocal of this value, or

$$C = \cdot 3183 \frac{n\ D_{\prime}\, t}{\phi\, E} \text{ microfarads.}$$

The unit No. 3 becomes defined symmetrically with, but independently of, No. 6, in consequence of the acceptance of the unit of inductive resistance. The unit of current is, necessarily, unit (static) quantity in unit time.

Practical Units of Measurement in Metre-Gramme-Second absolute units.

IN ELECTRO-STATICS.

1. *Electromotive Force*—

$$E = \textit{Volt} = \text{Veber} \times \text{Franklinad} = 10^{-2} \times 10^{7} = 10^{5} \text{ abs. Metre-Gramme-Second units.}$$

2. *Resistance, Inductive*—

$$R^i = \textit{Franklinad} = \frac{\text{Volt}}{\text{Veber}} = \frac{10^5}{10^{-2}} = 10^7 \text{ M-G-S. units} = \frac{1}{\text{Farad}}$$

$$\text{Megafrank} = \frac{\text{Volt}}{\text{Microveber}} = \frac{10^5}{10^{-8}} = 10^{13} \text{ M-G-S. units} = \frac{1}{\text{Microfarad}}.$$

3. *Quantity*—

$$Q = \textit{Veber} = \frac{\text{Volt}}{\text{Franklinad}} = \frac{10^5}{10^7} = 10^{-2} \text{ M-G-S. units.}$$

$$\text{Microveber} = \frac{\text{Volt}}{\text{Megafrank}} = \frac{10^5}{10^{13}} = 10^{-8} \text{ M-G-S. units.}$$

4. *Capacity*—

$$C = \textit{Farad} = \frac{\text{Veber}}{\text{Volt}} = \frac{10^{-2}}{10^5} = 10^{-7} \text{ M-G-S. units} = \frac{1}{\text{Franklinad}}$$

$$\text{Microfarad} = \frac{\text{Microveber}}{\text{Volt}} = \frac{10^{-8}}{10^5} = 10^{-3} \text{ M-G-S. units} = \frac{1}{\text{Megafrank}}.$$

IN ELECTRO-DYNAMICS.

5. *Resistance, Conductive*—

$$R = \text{Ohm} = \frac{\text{Volt}}{\text{Veber per sec.}} = \frac{10^5}{10^{-2}} = 10^7 \text{ M-G-S. units.}$$

6. *Current*—

$$I = \textit{Veber per second} = \frac{\text{Volt}}{\text{Ohm}} = \frac{10^5}{10^7} = 10^{-2} \text{ M-G-S. units}$$

$$\text{Microveber per second} = \frac{\text{Volt}}{\text{Meg ohm}} = \frac{10^5}{10^{13}} = 10^{-8} \text{ M-G-S. units.}$$

7. *Work* (or mechanical equivalent of heat evolved + work done)—

$$W = \textit{Joulad} = \text{Veber} \times \text{Volt} = 10^{-2} \times 10^5 = 10^3 \text{ M-G-S. units.}$$

The abs. M-G-S. unit of work being $\frac{1}{9\cdot 811}$ gram-metres, the Joulad = 101·926 gram-metres = ·7352 ft.-lb. = ·00096 calories English = ·24 calories French.

$$\text{Microjoulad} = \text{Microveber} \times \text{Volt} = 10^{-8} \times 10^5 = 10^{-3} \text{ M-G-S. units.}$$

NOTE.—In electrostatics, the initial E must be halved in order

* As might have been anticipated, the megafranklinad becomes, in practice, abbreviated to megafrank.

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to obtain the *mean* E acting during the period of charge or discharge. The formula for the work done in charging a condenser = the potential work or energy stored up in the charge, is, therefore—

$$W = \frac{\text{Vebers} \times \text{Volts}}{2} \text{ Joulads.}$$

Thus the potential energy stored up in a condenser of one microfarad charged from a source of 1 volt .... = ½ microjoulad, or ·0005 abs. M-G-S. units, or ·0000509 gram-metres, or ·0025 foot-grains.

—I am, &c., DESMOND G. FITZGERALD.

TELEPHONY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With your permission I will lay before the readers of *The Electrician* the particulars of some experiments in telephony, which I believe to be entirely novel.

It is well known that, if a piece of iron bar, free to move, is partially introduced into a helix of covered wire, and connection made with a battery, it is suddenly sucked completely into the helix. It struck me that on this principle a telephone might be constructed.

I accordingly very roughly put together a piece of apparatus represented in outline in Fig. 1, where D E is a wooden stand, A a toy telephone made by stretching some tracing linen over the end of a backing powder-box, B is a bobbin of thirty-six covered copper wire, such as is used in the Bell telephone. To the centre of the membrane of A I affixed a piece of thread, and

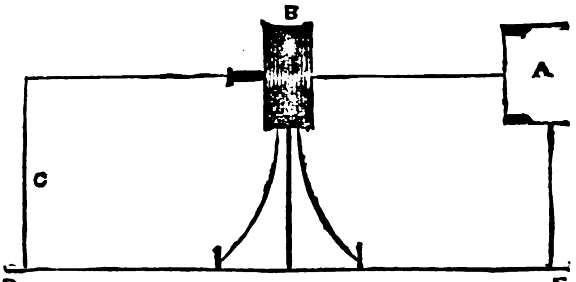


FIG. 1

to the other end of the thread a piece of iron wire about one inch long; another piece of thread was then tied to this wire, and passed through the bobbin B, the length of the first thread being such as to allow the iron wire just to enter the bobbin. The second thread being then drawn tight and fixed to the support C, kept the iron wire freely suspended in the hole of B. The ends of the wire of the bobbin were connected with binding screws on the base, and to these were brought the terminals of wires leading to a distant microphone.

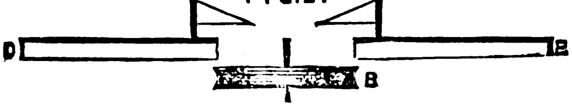
My idea was that the variable current from the microphone would cause the wire to enter the bobbin to different distances according to the strength of the current, and that this would cause a series of pulls on the thread leading to the stretched membrane. The first trial turned theory into fact. Not to the extent I had hoped however. Scratching on the microphone, and the rubbing of the finger along the base board were plainly reproduced, but singing and speaking proved a failure. However, I had heard enough to feel certain that in theory I was right, and that failure was attributable to the roughness of the apparatus. While meditating an improvement in this respect, the thought suddenly struck me, "Why not dispense with the thread connections and fix the wire immediately to the vibrating surface, the suction exerted by the coil will then draw the plate to and fro." I accordingly took up a rough piece of board about 8in. by 6in. in the centre of which there was a hole about 1½ inches in diameter; over this I screwed down the mouth piece and iron plate of a home-made telephone, on the other side I fixed the coil. To the centre of the vibrating plate I fixed by means of sealing wax an inch-and-a-half iron nail, so that it came just through the hole of the bobbin. The wires were then connected as before with binding screws. The arrangement will be understood by a reference to Fig. 2, where A is a mouth piece, B the coil of wire, C the nail fixed to the vibrator and just coming through the bobbin, D E the wooden stand.

On trying this arrangement the result was perfectly successful, singing and speaking were rendered excellently, the articulation being very perfect.

Here, then, we have a telephone equal in its action to the ordinary Bell's, but considerably simplified, and acting, moreover, on an entirely different principle. For use with the microphone it is cheaper and more compact, since it need not be more than two inches in diameter and two inches deep.

It may be said, however, that even here a part of the effect is due to the presence of the iron vibrator. I therefore removed it, and substituted a membrane of parchment, and, though the results were inferior, the difference was not more than might be accounted for by the inferior uniformity of the vibrator, as I found some difficulty in getting the parchment evenly stretched.

FIG. 2.



Unfortunately, although the above method provides us with another scientific toy more easily made than Bell's, it does not achieve what is the object of all telephonists—viz., to intensify the sound so as to be practically useful. What is required is an instrument that will speak out loudly and distinctly, and I feel certain that it is the transmitter that requires improving. Hughes's microphone is a long step in the right direction; but even in this the range of variation in the current transmitted is contained within too narrow limits.—I am, Sir, yours, &c.,

TOY.

P.S. The above apparatus can, of course, be used without battery by substituting small magnetised bars for the iron C in Fig. 2.

THE SUPERANNUATION FUND.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The statement, "We are glad, therefore, to be able to inform our correspondent (Mr. Forster) that the subject is at present being considered by the boards of, at least, two of the leading companies," in your issue of August 31, must, I am sure, have gladdened the hearts of hundreds of telegraphists at home and abroad; for, without the cognisance and assistance of the boards of directors, the foundation of Mr. Forster's humane scheme would be even as that of a house built upon the sand. But it is an idea which, in these days of enlightenment—when civilisation spreads apace—could not possibly meet with the disapprobation of any board, since its chief provision is the future support of veteran telegraphists who have worked and will continue to work faithfully and laboriously in the service of their several companies until the time of reaction shall overtake them.

In your friendly article you write that "a majority of the officials of our great cable companies have scarcely had time to look about them and reflect on their positions." Very true; but still, I will ask the minority, how many have yearned in the silence of their hearts for some solace when the future—dark and uncertain—has loomed before them like some dreaded phantom? How many have shuddered when age, clothed in all its infirmities, has presented itself to the mind's eye? The time must arrive when the eyes which are now clear and bright will become dim, and the joints of the pliant fingers will stiffen; when energy and activity will be replaced by languor and helplessness. And, then, what will the inevitable result be? Some of us must, of course, rise to comparatively independent positions; but the *vast majority—what are they to do?* Sir, this is a serious question, and I hope and trust that it will awaken those who have naught but a blank future before them to a sense of duty towards themselves and those dependent upon them; and that it will engraft within them a determination to develope and support the proposed fund to the best of their abilities.

Is it possible that we should continue to disregard the future—the holiday of life—by leaving it to chance when it is in our power while young to make provision for that time without detriment to ourselves?

If an institution can be established equal to that in vogue amongst railway companies, I think our requirements will be fully supplied.

Pending the decision of the boards, I think it would be premature to do anything further than appeal to the *employés* for their support; but I might add, in conclusion, that, assuming "fines" to be recognised necessities in all the companies, the "fine-money" would constitute a goodly item towards the expenses of the fund.—I am, Sir, yours, &c., SUPPORTER.

TO THE EDITOR OF THE ELECTRICIAN.

DEAR SIR: The chief object of this letter is to endeavour to interest you in a scheme which I am convinced is well worth your consideration, and which will confer an inestimable benefit on every one connected with the Submarine Telegraph service.

Considering the number of men engaged in the service, it is a

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matter for great surprise that there is as yet no pension fund connected with it. The explanation is probably to be found in the fact that we are scattered in small groups all over the face of the earth, which renders unanimity of action impossible.

There are very few who would not be glad to pay a small percentage on their salaries to secure themselves from having to linger out the evening of their days in a workhouse, a fate which at present stares us all in the face. For the utmost an operator could save in—say, twenty years of service would be 2,000*l.* (two thousand pounds), supposing he did not marry, and was all the time at very cheap and consequently out-of-the-way stations. That is to say, after living "the most miserable life in the world" for his best years, he would come home with just enough to keep himself alive! I believe, sir, that it would also *pay* the various companies to promote a pension fund—that is to say, if they prefer retaining old servants to taking on new ones, which, in the case of one large company, I am very much inclined to doubt. For operators who had subscribed to the fund for some years would not feel inclined to leave the service, and for many reasons would exert themselves to the utmost and endeavour to reach the highest positions. Most of the members of the service are still young, and if the fund is started at once we shall have to pay but a small percentage.

If the managing directors of the various companies would take the matter into consideration, form a prospectus, and send it to the superintendents of all stations, and arrange for the management of the fund in London, I have no doubt that next year our miserable lives would be cheered by the thought that they would not end in the melancholy way I have above alluded to.

Trusting, sir, that the importance of the subject will excuse the length of my letter, and wishing your paper the success it well deserves, I beg to reman, yours truly,

El Prudente.

[The above is the conclusion of a letter from the antipodes, the first portion of which earnestly invites us to call attention to the position of operators. The writer cannot yet have received the numbers of *The Electrician* calling attention to this subject, and is, therefore, ignorant of what has been done. We need hardly say that we shall be glad to receive the opinions of all readers interested in this subject; and we are glad to learn that the directors of some of the companies are carefully considering the suggestions respecting a pension, or some similar fund.—Ed. *E.*]

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).

The half-yearly general meeting of the shareholders of the above company was held at their offices, No. 106, Cannon-street, on Thursday, the 26th of September, under the presidency of Mr. N. Bannatyne.

The report of the directors stated that the payment of the dividend of 10 per cent. on the preference shares would absord 2,921*l.* of the balance of profit and loss, leaving a sum of 490*l.*, or only 21*l.* short of the amount necessary to pay the arrears of 1*s.* 9*d.* per share still outstanding on the preference shares. The directors, therefore, recommended that the amount necessary to pay off these arrears should be taken from the reserve fund. The total receipts from telegrams in the half-year had been 5,012*l.*

The Chairman, in moving the adoption of the report, said the shareholders would no doubt observe with satisfaction that the company's cables were in the same high electrical condition as at the time of the last report; and, from the reports they had since had from their electrician, the state of the cables was as satisfactory as ever. In confirmation of this he might mention a fact which, no doubt, would be satisfactory to the shareholders. The other day they had to uncover the shore end at Barcelona in some little operations they had to make, and not only did they find the shore end of the cable there in perfect condition, but even the yarn and compound forming the external covering of the cable was in as perfect a condition as on the day when it was laid; and they must remember that the Barcelona and Marseilles cable had been down for four-and-a-half years. This, of course, was highly satisfactory. He was glad to say that the hopeful signs of a revival of business in Spain, which had begun to manifest itself in an increase in their receipts from the beginning of August, had continued, and had resulted in the month of September in a considerable further increase. Their receipts, which in July, 1877, were 823*l.* were in the same month this year 811*l.*, showing a slight diminution; but in August last they amounted to 878*l.*, as compared with 790*l.* in August, 1877. In September last year they were 812*l.*, and so far as they could judge from the number of days which had expired of September this year, their receipts would be over 1000*l.*, showing an increase of over 25 per cent. They did not like to prophesy as regarded the future, but at the same time they were just at the beginning of the first season, the prospects of which were very good this year; so that they thought they might reasonably anticipate the continuance of a considerable increase over last year. He would just give a few figures, not prophesying anything. Of course, they could not anticipate the future, for they were liable to contingencies; but, as he had already said, their receipts for September would be over 1,000*l.* Supposing they could average 1,000*l.* a month for twelve months, they would be able to pay their preference dividend in full, put 700*l.* to reserve fund, and pay 2*s.* a share on the ordinary shares. A further increase of 50*l.* a week—their working expenses would be the same, even though they had a large increase—or, say, altogether 1,200*l.* a month for twelve months, would enable them to put, in all, 1,800*l.* to reserve, and, instead of paying 2*s.* a share, they would be able to pay 4*s.* a share on the ordinary shares. They had now on their list 73 ordinary shareholders, and 151 preference shareholders, which was an increase, again, on their preference shares, showing that they were coming more into favour. As regarded their expenditure, they would see that it was about the same as usual. If the expenses connected with the removal of their offices in Barcelona and Marseilles were deducted from the regular expenditure, that was still below the expenditure of the corresponding half year of about 20*l.* If anything, therefore, they were diminishing their expenditure.

Mr. Abraham Scott, one of the directors, briefly seconded the motion, and expressed his belief that the long period of depression which we have had was drawing to a close, and that there was a hope of better times.

Dr. Beattie thought the remarks of the chairman, taken in connection with the statements in the report, must be considered very satisfactory. One of the most favourable features of their undertaking, if not the most satisfactory, seemed to him to be the solid and substantial condition of their cables.

The Chairman then put the motion for the adoption of the report, and it was carried unanimously. Subsequently he moved the payment of the dividend recommended on the preference shares.

Mr. Etlinger seconded this resolution, which was also carried unanimously.

A vote of thanks to the chairman and directors then terminated the proceedings.

THE ELECTRIC LIGHT AND THE GAS COMPANIES.

The half-yearly general meeting of the London Gas Light Company was held on Wednesday, the 2nd inst., at the Freemasons' Tavern, Lincoln's Inn-fields. The Governor, Mr. M. R. Hawkins, presided, and in moving the adoption of the report, said they had all heard of the electric light, and he thought they must see that there were yet difficulties in the way of its introduction, and material difficulties in making it do what some tried to make them believe it would do, or they would not see this discovery "hang" as it did. It was also very difficult to get anything like authentic information about it; and they might assume that there were yet material and financial difficulties in connection with its introduction, or they would have heard more about it. Month after month they saw that it was applied over only a very small area. The shareholders must remember that if science was developing electricity it was not standing still as to gas; and, in fact, science had aided them very materially. Their gas, for instance, was cheaper and better than it used to be, partly owing to science, and partly to mechanical improvements. Science had given value to a number of materials which formerly were a mere drug, but from which now gas companies derived a considerable income. The electric light had very little heat in it, while gas, on the other hand, could produce a great deal of heat. It was used very largely in cookery, and its use was daily increasing, although for such purposes gas was as yet in its infancy. The electric light could only be produced by means of an engine, and if it were ever used in places where people were able and willing to afford it, he believed that gas would be the material used in order to produce the electric light. He had not the slightest doubt that if their future was at all affected by the electric light it would be improved rather than injured, and he believed, indeed, that it would open a new field altogether to them.—Lord Kinnaird formally seconded the motion; after which Mr. Leng, of Dundee, said that there had lately been a serious fall in gas stock, and the directors did not seem to think the cause of it worth the slightest notice in the reports which they issued to the shareholders. The directors of that company were not so conservative as those of the Chartered Gas Company, who, dealing with a property valued at nearly nine millions, thought nine lines of print sufficient for their last half-yearly report, although their property had been depreciated in the market during the half year between one and two millions. The only thing he could not understand was, why the shares of the London Gas Companies did not generally stand much higher; for, to all intents and purposes, this and similar companies had a Parliamentary guarantee of 10 per cent. dividends so long as they supplied gas at prices which there was no doubt of their ability to supply at. Why, then, without any fall in the dividends, had there been such a fall in the value of gas stocks? In reply to this question he had been told that an electric light had been put up in the Strand, and straightway the Cockneys concluded electricity was going to supersede gas, and so they were throwing away their gas stock. Now, he had been studying the electric light for more than two years, and more particularly for some months past. He was a great believer in the electric light; at the same time he did not believe it would injure the property of the gas companies one farthing. He had seen the electric light used through two successive winters in the construction of the Tay Bridge; he had seen it used several nights during the demolition of a public building; he had seen experiments with it by two of the ablest scientific men in Scotland; he had seen it used frequently for street illumination; and he had seen the best effects obtained from it in Paris. He had also read all the books, pamphlets, and articles upon the electric light on which he had been able to lay his hands, and the conclusion at which he had arrived was that the electric light would be one of the lights of the future, but not to the excluding or superseding of gas-light. Dr. C. William Siemens, the highest authority on the subject in this country, in his lecture in Glasgow on the 14th March, said:—"There is this further inconvenience connected with the electric light, that its rays are so intense that they must not reach our eyes without having first been softened down, either by the interposition of some semi-transparent substance, such as ground glass, or by directing the light against screens, or against the ceiling of the room, as was suggested by the Duke of Sutherland, so as to illuminate by reflection only. . . . Its practical application for large halls and places where powerful light effects are required will, therefore, be a question only of time, while for domestic purposes gaslight will long continue to hold its own owing to the greater facility which it offers of subdividing the effects of light, and of accommodating its intensity to immediate requirements by simply opening and closing an ordinary tap." The latest and most com-

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plete work on electric lighting was the "Practical Treatise," by M. Hippolyte Fontaine, translated by Dr. Paget Higgs, and which, while strongly advocating electricity as "eminently convenient for the lighting of large uncovered spaces or large halls without interior partitions," says, "when it is required to light small places, or even sub-divided localities, it is much more advantageous to supply gas, petroleum, or even ordinary oil." If, then, even oil and petroleum were better suited for small places than the electric light, need they be afraid of gas? An important statement was made at the recent meeting of the Gaslight and Coke Company, that the whole proportion of the lighting of the streets was less than 1 per cent. of the total supply. If, therefore, all the public lighting together were done by electricity it would not affect the gross revenue 1 per cent., and the effect on the net profit and dividends would be imperceptible. The directors of gas companies, however, must look the facts fully in the face. There was no doubt that in certain places and to a certain extent the electric light would be adopted, and would be usefully applied. Seeing then that the Gas Companies were established to supply artificial light, why should they not undertake also this latest and most scientific method of illumination? They had a preferential claim to undertake such supply, and everything, he said, pointed to the Gas Companies as being the proper parties to undertake the supply of electric as well as gaslight. He would, therefore, urge the directors and officials of that and every other gas companies to consider the electric light, not with the view of rejecting but of adopting it as auxiliary and complementary to gaslight.—Mr. Robert Rawlinson, C.B., one of the directors, expressed his general concurrence in the remarks of Mr. Leng. He himself had just returned from Paris, where he had seen the electric light in operation. It was a beautiful light, but it was very unsteady. This drawback might be improved, but it was quite clear from the scientific explanations with regard to the power required to use and distribute it, that it could not come into competition with gas for general purposes. Its use necessitated the employment of a powerful engine at short intervals. He regretted the ruinous sacrifice made by some shareholders in consequence of the "scare" created by the light. The use of gas was now general and very extensive, but not nearly so general or extensive as it would yet be made; and, if the electric light was in any way to be used, his firm opinion was that the power required to drive the machine would be produced by gas. He quite agreed that the light was not to be pooh-poohed.—A Shareholder observed that the electric light was put out at twelve o'clock in Paris, and the use of gas was resumed. In Paris, too, gas was 7s. 6d. per 1,000 feet.

The half-yearly general meeting of the Phœnix Gaslight and Coke Company was held on Wednesday, the 2nd instant, at the Bridge House Hotel, London Bridge. The chair was occupied by Mr. Edward Horner, who congratulated the shareholders on the continued prosperity of the company, and detailed the results of the half year's working. The new gas-holder at Kennington, the largest in the world—containing over 3,100,000 feet of gas—and the new gasholder at Greenwich would be used this winter. Referring to the electric light, he alluded first to the great attention which it had excited, and the apparent fear it had created in the minds of some of the shareholders in gas companies. Since their last meeting a deputation of the directors, accompanied by scientific assistance, had visited Paris, and they had to thank the officials connected with the electric light, and every one in Paris for the facilities and the information afforded them. The electric light, he then observed, was not a thing to be pooh-poohed. No doubt it was a very beautiful light, and it would certainly have the effect of drawing attention to further improvements in the manufacture of gas, and would, he was sure, lead to the more extended use of gas, which was very economic, and could be used with the greatest facility. Beautiful as the electric light was, everything must resolve itself into a question of cost, and he would give them some figures resulting from the visit to Paris. At one of the large hotels there they had the electric light. They had forty-eight gaslights, and a calculation was made that they cost, at the Phœnix Company's price for gas, 3s. 4d. per 1,000 feet, 4s. 10d. a night. In place of the forty-eight gas lights eight electric lights had been substituted, and their cost was estimated at 1*l*. 13*s*. a night. The Avenue de l'Opéra, a more important place, was estimated to cost for gas 885*l*. a year, whereas the estimated cost of the electric light for the same number of hours was 10,625*l*. In Paris there was one electric light to five gas lights, but it had been suggested that, if there were fifteen gas lights to one electric light, there would be a most magnificent light in the street, and that would only cost 2,256*l*., as against 10,625*l*. Shareholders should also bear in mind that of all the business done by gas companies in London that of street lighting was of the least consequence; in their own case he estimated that 1*d*. per 1,000 feet over the whole concern should cover the whole public lighting of this company. He thought that there was nothing to fear from the electric light. Gas was perfectly under control; more or less of it could be used, but in the case of the electric light they must accept the blaze of 300 candles, and they could obtain no modification of this; it was, he said, utterly unmanageable.—The motion having been seconded, Mr. Leng said the great error into which public companies, like private individuals, were apt to fall, was in setting their faces against, instead of promoting improvements—in thinking they ought to oppose what it was their real interest to encourage and turn to account. Now, he confessed he was an enthusiast for the electric light; but his enthusiasm was tempered by business calculation. He considered the electric light a splendid light for some purposes and in some places; but, after careful inquiry, he had come to the conclusion that there were few purposes and few places for which as yet—he emphasised *as yet*—the electric light could be adopted, having regard to the cost and the method of supply. As an illustration, he mentioned that the printing and publishing establishment of which he had the charge contained nearly 300 gaslights, about one-third of which burnt all night for six nights a week. The cost of the gas was 200*l*. a year, or on the average 12*s*. 6*d*. per night. No attendance was needed, and the original cost of the gas-fittings was only about 200*l*. Now, he had obtained an estimate for lighting the same establishment with the electric light, and he found he would need 15 Gramme machines, which, at 100*l*. each, would cost 1,500*l*. Then the carbons would cost 3*d*. per hour for each light, being 3*s*. 9*d*. per hour, and it would take steam engines of about 30 horse power, costing, say 1s. 9d. per hour, to drive the electric machines. Leaving out of account, therefore, the large original outlay—the interest and wear and tear of which would be equal to about 200*l*. a year—the electric light would in his establishment cost 5*s*. 6*d*. per hour against 12*s*. 6*d*. the whole night for gas. Not only so, but one if not two men would be needed to attend the electric burners and see that they acted properly, while the gas needed no attention whatever. It was clear, therefore, that at present in works like his electricity would not be substituted for gas. There were, however, others for which it was better adapted, such as railway depots, foundries, and engineering establishments; and a large manufacturer in Dundee who had tried the electric light believed it would come to be generally used in spinning mills. It was already in use in some twenty or thirty such works on the Continent. At the present time the application of the electric light was in its infancy, but if they were wise they would not shrug their shoulders and put up their backs and say it would never come to be generally used. With regard to the electric light, as with regard to gas, steam, and the electric telegraph in the past, great improvements in detail would yet be made, and it was for the gas companies, looking forward to the future, to place themselves in a position to take advantage of those improvements and turn them to account.—The Chairman, in the course of his reply, said in Paris they had no less than 400 horse-power employed in lighting 179 electric lights. As to the company's taking up the electric light, he was afraid if they tried to do so they would be told they had no Parliamentary powers.—The report was then adopted.—Mr. James Shand, M.I.C.E., the deputy chairman, in moving the dividend resolution, said there was no doubt that gas properties would remain uninjured by the electric light. Even the Paris Gas Company's shares had not fallen, and its only effect there had been to prevent the further rise in their value.

At the half-yearly meeting of the Harrow District Gas Company, held at the Guildhall Tavern on the 26th ultimo, Mr. James Glaisher, F.R.S., the chairman of the company, presided, and in the course of his remarks, in moving the adoption of the report, said—The next thing I should like to make a few observations upon is in reference to the electric light. Electricity has always been a matter of considerable interest to myself as regards its applicability to the wants of man, and at the present time my attention is particularly directed to it as applied to the lighting of large spaces. I believe it is very applicable to that purpose, if it can be produced cheap enough. The question is, is it possible to introduce the electric light at such a cost that we are not paying too much for it? In Paris, you all know, gas is sold at a high price, and so far as I have been able to collect information, the electric light costs a great deal more. At the present moment there are four carbon candles in each lamp, and it is a question to my mind whether, throughout the whole of the coming winter, when the nights will be so long, the electric light will be continued in Paris. Take those they even now have in Paris. Only two lights can be placed on each wire, as, if there is a third or fourth light, the wire is fused, and all of them are put out. I believe there are three or four engines at work, and if gas is used for the heating power, more would be required than would be necessary if used for lighting. But then comes this question. Mr. Sugg has improved gas burners so as to make bad gas give a good light. He has produced a burner giving an illuminating power of almost 300 candles, and this will rival in brightness that of the electric light. It is a diffused light, pleasant to the eye, and not painful to look at, so that it may happen that if all our large spaces are to be lighted it will be by gas, and not by electricity, and yet it will be equally beautiful. Viewing it in every way I will not part with a single gas share I possess.—Mr. John Chapman, the deputy-chairman, in seconding the motion, also observed that he did not know of one shareholder in the company who contemplated parting with a share on account of the electric light, and he trusted that this would be the resolution of every shareholder in the company.

RECENT PATENT.

408. Controlling and Localising Electric Currents, *L. de B. y O'Lawlor.—Dated 21st January*, 1878. 10*d*.

In order to send communications to or from a central station to any one station in the circuit, a modification of the "autoquinetic" system of line wires, and blocking and preparing apparatus described in patent No. 1303, dated 27th March, 1876, is employed, and in connection therewith any suitable sending or receiving instrument. The arrangement of line wires consists of two separate wires, one for transmitting signals and the other for effecting the release of the commutator mechanism at the different stations, and for operating the localising instrument at the central station. This apparatus consists of a battery connected with a bobbin and electro-magnet, and with the starting wire. The armature of the magnet acts when a current passes through the bobbin upon the retaining mechanism of a clockwork arrangement, which, when liberated, sets in motion a feeling instrument caused to traverse a path, at various points of which, corresponding in order to that of the houses in the circuit, a pin may be placed.

TELEGRAPHIC INTELLIGENCE.

Atlantic and Pacific.—The Executive Committee in New York have declared a dividend of ½ of 1 per cent. out of the net earnings since the pooling contract was executed, up to August 1, being the first dividend ever paid by the company. It is semi-officially stated that it is the intention of the executive committee to declare quarterly dividends hereafter, so as to create a 3 per cent. dividend stock. It is stated that there will be no further proceedings in the Benedict suit, and that the Western Union Company will at once pay over the deferred earnings under the pooling contract.

Western Union Telegraph Company.—The report for the quarter ending September 30, 1878, furnishes the following:—The official returns for the quarter ending June 30 showed the profits to be $853,329, or $3,629 less than the estimate. The following revised statement, based upon com-

plete returns, will show the condition of the company at the close of the quarter ended June 30, 1878:—

Surplus April 1, 1878, as per last quarterly report		$188,859
Net profits, quarter ended June 30, 1878		858,329
Amount charged into the current expenses of the year ended June 30, 1878, for material and supplies which were on hand and paid for, but which were not included in the surplus		30,515
Total		$1,077,703
From which deducting—		
Dividend of 1½ per cent., paid July 15, 1878	$525,936	
Interest on bonded debt	107,976	
Interest on amount due for purchase of Atlantic and Pacific Telegraph stock	2,171	
Sinking funds appropriation	20,000	
Construction account	40,632	
Purchase of sundry telegraph stocks, patents, &c.	11,904	$708,620
There remained a surplus July 1, 1878, of		$369,083
The net profits for the quarter ending Sept. 30 inst., based upon official returns for July, nearly complete returns for August, and estimating the business for September, reserving amount sufficient to meet the claims of the Atlantic and Pacific Telegraph Company under existing agreements, will be about		$1,001,364
Add surplus July 1, as above		369,083
From which appropriating—		$1,370,448
Interest on bonded debt	$107,000	
Interest on purchase of Atlantic and Pacific Telegraph stock	2,000	
Construction, purchase of stock of leased lines, &c.	50,000	
Sinking funds appropriations	20,000	$179,000
Leaves a balance of		$1,191,448
A dividend of 1½ per cent. on the capital stock outstanding requires		525,936
Deducting which, leaves		$665,512

In view of the preceding statements, the committee recommend a dividend of 1½ per cent., payable October 15.

Eastern Telegraph.—This company announce the payment of an interim dividend of 2*s.* 6*d.* per share on the ordinary shares on the 14th of October next in respect of the profits for the quarter ended 30th of June, 1878, and a dividend of 3*s.* per share on the Six per Cent. Preference Shares, less income-tax, for the quarter ended the 30th of September, 1878, will be paid on the same date. The half-yearly interest on the Six per Cent. (1873) Debentures will be paid on the 15th of October at the banking-house of Messrs. Glyn, Mills, Currie, and Co., 67, Lombard-street.

Eastern Extension, Australasia, and China Telegraph.—An interim dividend for the quarter ended June 30 of 2*s.* 6*d.* per share, or at the rate of 5 per cent., has been declared.

West India and Panama Telegraph.—The secretary writes that the directors have decided to place 5,000*l.* to reserve, recommending a dividend at the rate of 1 per cent. per annum, free of income-tax, on the ordinary shares of the company for the half-year ending the 30th of June, 1878, in addition to the dividend at the rate of 6 per cent. per annum on the first and second preference shares of the company.

Reuter's Telegram.—The directors have declared an interim dividend at the rate of 5 per cent.

The Midland Railway traffic receipts of the past week show a decrease of 1,377*l.*, and so far this half year an increase of 8,726*l.*

The traffic receipts of the North Eastern Railway Company for the past week show a decrease of 4,793*l.*, and so far this half year a decrease of 74,379*l.*

The receipts of the Great Eastern Railway Company for the past week show an increase of 2,087*l.*, and so far this half year an increase of 27,879*l.*

The receipts of the Great Northern Railway for the past week show a decrease of 1,808*l.* as compared with this time last year, and so far this half year an increase of 16,753*l.*

The traffic receipts of the Great Indian Peninsula Railway Company for the week ending August 10 show a decrease of 29,067*l.*, as compared with last year.

TELEGRAPH SHARE LIST.

Amount of Issue.	Amount of Share.	Paid on Share.	Company.	Reserve as per last Report.	Dividends calculated at rate per cent. per annum. 1875. %	1875. %	1876. %	1876. %	1877. %	1877. %	When Payable.	Prices. 1875. Highest.	1875. Lowest.	1876. Highest.	1876. Lowest.	1877. Highest.	1877. Lowest.
£3,254,580	Stock	100	PAnglo-American	Deferred receiving no dividend until 6 per cent. has been paid to Preferred.		year.	5	4†	3	5	† Div. 5 % per ann. for quarter ending Dec. 31, 1876, 2% for quarter ending Mar. 31, 4 % for quarters ending June 30 and Sept. 30, 6 % for quarter ending Dec. 31, 1877, and 4 % for quarter ending March 31, 1878.	75½	51½	68½	53	62¼	52
1,872,710	Stock	100	Do. Preferred B		—	—	10	2	6	6		Crtd	1876.	93	75	88½	79
1,872,710	Stock	100	Do. Deferred A		—	—	Nil.	6	Nil.	4		Crtd	1876.	44	29	38	25½
1,300,000	10	All	Brazilian Submarine	120,000	5	5	5	5	5	5	Quarterly.	7¾	6	7¼	5¾	6¾	5⅞
160,000	10	All	Cuba (Limited)	—	—	—	—	—	—	—	——	—	—	—	—	—	—
60,000	10	All	Do. 10 per cent. Preference	—	—	—	—	—	—	—	——	—	—	—	—	—	—
116,379	10	9	Direct Spanish (Limited)	—	—	—	—	—	—	—	——	—	—	—	—	—	—
58,430	10	All	Do. 10 per cent. Preference	—	—	—	—	—	—	—	——	—	—	—	—	—	—
65,000	20	All	Direct United States	Nil.	—	Nil.	Nil.	Nil.	Nil.	5	Quarterly.	13	7	11½	6¼	13½	9½
369,700	10	All	Eastern (Limited)	110,000	5	year.	5	5	5		aJany., April, July, Oct.	8	6⅝	7⅛	5	8¼	6⅜
232,000	100	All	Eastern 6 per cent. Debentures	—	—	—	—	—	—	—	——	—	—	—	—	—	—
200,000	100	All	Do. 5 per cent. Debentures	—	—	—	—	—	—	—	——	—	—	—	—	—	—
700,000	10	All	Do. 6 per cent. Preference	—	—	—	—	—	—	—	——	—	—	—	—	—	—
1,997,500	10	All	Eastn. Exten. Australasia & China	125,404	5½	year.	5	year.	5	year.	aJany., April, July, Oct.	8¼	7	7½	5⅛	8	6¾
320,000	100	All	Eastn. Exten. 6 p.c. Deben. (1875)	—	—	—	—	—	—	—	——	—	—	—	—	—	—
192,680	10	All	German Un. Tl. and Tst.	—	—	—	—	—	—	—	——	—	—	—	—	—	—
1,500,000	10	All	Globe Telegraph and Trust	Nil.	5	7 4-5	4½	7 5-6	3⅜	7 6-7	bJany., April, July, Oct.	6¾	5⅛	5⅞	4¼	5¼	4¼
1,500,000	10	All	Do. 6 per cent. Preference		6	6	6	6	6	6	Jany., April, July, Oct.	10½	9¾	10⅛	9½	10⅛	9½
150,000	10	All	Great Northern	85,543	5⅝	year.	6⅝	year.	6⅝	year.	5 % intrm. Jan. 1, July 1. Final Dividend April.	11½	7½	9¾	7	8	7
			Shares to Bearer, or can be Regstrd.														
—	25	All	Indo-European	—	—	—	—	—	—	—	——	—	—	—	—	—	—
120,000	10	All	Mediterranean Extension (Lmtd.)	—	—	—	—	—	—	—	——	—	—	—	—	—	—
32,000	10	All	Do. 8 per cent. Preference	—	—	—	—	—	—	—	——	—	—	—	—	—	—
—	18	All	Reuter's (Limited)	—	—	—	—	—	—	—	——	—	—	—	—	—	—
65,000	10	All	West India and Panama	16,000	Nil.	Nil.	Nil.	Nil.	1	1	‡ Converted from a 10 %	4¾	1⅜	2½	⅛	3⅝	1½
34,563	10	All	Do. 6 per cent. Preference		7/6ac	year.	10/ac	year.	6‡	6	into a 6 % 1st Preference.	12	9	11	7	11	7½
67,500	20	All	Western and Brazilian	7,793	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Half-yearly.	18¼	9½	10⅜	4½	5¾	4½
$1,500,000	$1000	All	Western Union Telegraph 7 per cent. First Mortgage Bonds	—	7	7	7	7	7	7	May, November.	108	102½	109¼	105	113	106
£1,030,000	200	All	Do. 6 per cent. Sterling Bonds	Redeeemable by annual drawings at par.	6	6	6	6	6	6	March 1, September 1.	93	86	98	89	101	94

a Year ends March 31st. Interim Dividend of 5 per cent. Final dividend in July.

b Year ends July 18th. Final dividend in July.

Companies.	Closing Prices Oct. 2.		Business Done Week Ending Oct. 2. Highest.	Lowest.
Anglo-American	59¾,	60¼	61½	60¼
Do. Preferred	88¾,	89¼	90½	90
Do. Deferred	32¾,	33¼	34½	33¼
Brazilian	6 13-16, 15-16		7	6 15-16
Cuba	9¼,	¾	9½	—
Do. Ten per Cent. Preference	15¾,	16¼	16	—
Direct Spanish	2¼,	¾	2½	2½
Do. Ten per Cent. Preference...x d.	10,	½	10½	10½
Direct United States	12¼,	¾	13½	12¾
Eastern	7 5-16, 7-16		7 9-16	7⅜
Do. Six per Cent. Debenture	107,	109	—	—
Do. Five per Cent. do.	99,	101	—	—
Do. Six per Cent. Preference	11¼,	¾	11½	—
Eastern Extension	7¼,	¾	7 7-16	7 5-16
Do. Six per Cent. Debenture	106,	109	108½	—
German Union	8,	½	—	—
Globe Telegraph and Trust	5¼,	½	5 5-16	5¼
Do. Six per Cent. Preference	10½,	11	11	10⅞
Great Northern	7½,	8	—	—
Indo-European...x d.	20,	21	20½	—
Mediterranean Extension	3,	½	—	—
Do. Eight per Cent. Preference	9½,	10	—	—
Reuter's	10,	11	—	—
Submarine	216,	221	—	—
West India and Panama	2¼,	¾	2½	2½
Do. Six per Cent. Preference	8¼,	¾	8½	—
Western and Brazilian	2¾,	3¼	3	2½
West. Union Seven per Cent. 1st Mortgage	114,	118	—	—
Do. Six per Cent. Sterling	101,	103	101½	100½

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NOTES.

The West Coast of America Telegraph Company (Limited).—The traffic receipts for the month ending Sept. 30th, 1878, amounted to £2,200.

The Eastern Telegraph Company (Limited).—The Eastern Telegraph Company's Traffic Receipts for the month of September, 1878, amounted to 38,169*l.*, and to 35,440*l.* in the corresponding period of 1877.

Great Northern.—Information has just been received that the Great Northern Telegraph Company's Nagasaki-Shanghai cable has been repaired. Messages for Shanghai will, therefore, again be forwarded in regular course by the company's lines.

Eastern Extension Telegraph.—The company notify that their cable between Java and Australia is interrupted. Telegrams for Australia and New Zealand will be forwarded between the interrupted points until communication is restored by the special steamer chartered by the Australian Governments.

Cuba Submarine.—Information has been received by the Cuba Submarine Telegraph Company that their 1870 cable between Cienfuegos and Santiago, which was repaired in April last, has been again broken. There is, however, no interruption to business, communication being maintained by the duplicate cable laid in 1875.

The Teredo and Cables.—A new invention, intended to defy the efforts of these and similar enemies to cables, is in course of trial by the Eastern Extension Company. Several hundred miles of cable covered with a preservative of brass tape has been sent out for use; and, in fact, some of it is already laid. We trust that by the means adopted the danger to cables from holes made by the teredo may be averted.

Mechanical Telephone.—An improved Mechanical Telephone has been patented by Messrs. Schuyler S. Parsons, Francis R. Shaw, and George N. Daniels, of Chatham Center, Ohio. This invention consists of a diaphragm of cloth or other textile fabric, mounted in an open wooden case. The transmitting wire branches out in a number of smaller wires joined to the main wire, and attached to the diaphragm. The main wire is hung to insulators made of sheepskin, placed in a frame with a central opening, the frame and sheepskin being slitted, and the latter re-enforced at the slit.

An Inventor's Difficulties in England.—In a letter to a friend in America, Mr. Graham Bell, the inventor of the telephone, gives an amusing account of the difficulties he has experienced, while in England, in getting other than routine work done. He says:—"If you want to know the reason why inventors are more numerous in America than they are here, come and live for six months in England. If you wish to know how it feels to be brimful of ideas, and yet to be unable to have one of them executed, come to England. If you wish to know how it feels to have to wait for a month to have the simplest thing made, and then to be charged a man's wages for two months, come to England. You will here be unable to see the interior of a workshop or to come into direct contact with your workmen, and the people seem incapable of working excepting in the ruts worn out by their predecessors. They are absolutely incapable of calculating any new design without the most laborious oversight from the inventor, and their masters, instead of encouraging invention, do all they can to put a stop to it, by refusing admission to the workshops, and charging the most exorbitant prices for experimental work, avowedly because they 'don't want such kind of work,' 'it gives more trouble than it is worth,' and 'if you must have new things made you must expect to pay for them.' It is in vain that I say I have no objection to pay if I can only be allowed to oversee my own work. It is in vain that I say I am willing to pay anything to have my work done, and that what I object to is having to pay for not having it done. It is the same everywhere. Not only is your work not done, but you have to wait so long for the simplest things that your ideas cool, and you get quite exasperated at your inability to do anything." It would be interesting to know whether inventors in other fields are similarly hindered. Just now it seems to be especially difficult, for anyone not connected with or favoured by the English Telegraph Department, to get anything done in the way of telephones or telegraphy. Possibly, that is the source of Mr. Bell's troubles.—*Scientific American.*

The Electric Light. — The following is taken from a contemporary who, in our opinion, somewhat underrates the present and prospective position of electricity as an illuminating agent:—"We have been favoured with a perusal of an independent report on the electric light as used in Paris, made by a gentleman fully competent to form a scientific opinion, and intimately acquainted with the subjects of electric and gas lighting in all their various aspects. He went to Paris to judge of the new illuminating power, and to form an estimate of its utility and practicability, with the view of definitely deciding whether he could recommend its adoption in this country. The question is fully entered into by him, and discussed with a judicial calmness. He reports that the light sometimes suddenly goes out, and instances an occurrence about three weeks ago when La Place de l'Opéra, which has the electric light throughout, was suddenly left in utter darkness, and the old gas lamps had to be utilised to illuminate the street. At its best the light is uncertain in its brilliancy, varying as much occasionally as 30 or even 50 per cent. From the extreme intensity of the light, a globe is necessary to make it endurable, but an albatrine globe reduces the power of the light by about two-thirds, a matter not taken into account by the electricians in estimating the cost of production, for they count the cost and brilliancy of the *naked* light. To work the engine necessary to produce the electric light a *gas* engine is required. The light cannot be sub-divided without great expense, and a division of such a strong light is an absolute necessity, and, as the more it is divided the more the expense, it seems that before a *bearable* light can be supplied the cost will be far in excess of gas. He points out how it is possible that as a means of *advertisement* people will use it, and mentions how the use of it at the Gaiety Theatre has been a very successful advertisement for the manager. He alludes to the fact that the Dover lighthouse has been lit by electricity for some fifteen years, and so little advance has been made scientifically since that time that the light which now "scares" the public is materially identical with the one in use this half-generation. He is of opinion that we are as near the discovery of perpetual motion as the invention of any means whereby electricity will supersede gas, and he sums up by saying that it is *impracticable* for street lighting and *impossible* for household purposes. We must say that, if anything can be satisfactorily proved to demonstration, it has been fully proved that the fears in respect to the electric

light are groundless and almost absurd. It is, however, a matter for the study of psychologists how it comes to pass that in the minds of intelligent people a disproved thing is believed in more than a fully and clearly proved matter. But the human mind is a paradox writ large, and we are confident that by-and-bye gas shareholders will repent the ill-timed and unreasoning timidity which made them sacrifice their property."

Extraction of Steel and Iron from the Eye by the Magnet.—The following cases are taken from the *Lancet*:—"Dawson B——, aged twenty-four, smith's helper, applied to me at the hospital on January 16, 1877. He stated that three days previously his right eye had been wounded by a small piece of metal. I observed that the iris was attached to the lens at the outer part of the pupil by recent lymph, and that there was a limited opacity of the lens. There was a small clear metallic body sticking at the margin of the adherent pupil. I made a small section of the cornea, more peripheral than the pupil, introduced a pair of iridectomy forceps, and seized the body and a little piece of iris; but the body slipped from my grasp, and was gliding out of my reach. Fortunately, I had anticipated such an untoward event, and took care to have a pointed permanent magnet at hand. I introduced it into the wound. The metal was instantly attracted and withdrawn. The patient continued under my observation till February 16. The opacity of the lens remained limited to the part wounded. I believe the wound in the capsule was closed by lymph and healed. I have not seen or heard from the patient since."—"Moses E——, aged thirty-two, millwright, consulted me at the hospital on November 20, 1877. He stated that three-quarters of an hour before his visit his right eye had been wounded by a chip of steel from a hammer. I observed a wound a little more than a line long in the ciliary region, just at the corneo-sclerotic junction. One end of the wound penetrated the anterior chamber, as shown by the evacuation of the aqueous humour and a slight displacement of iris toward wound. The wound was quite clean, and no foreign body was visible. Media clear. Ophthalmoscope did not disclose presence of foreign body. I put the point of the magnet cautiously into the wound, and at once it proved the presence of metal within the sclerotic by the click and the attraction. By a little patient and careful use of the magnet the metal was brought into the wound, and the end of it exposed so far as to enable me to seize it with forceps. Having caught it, I easily extracted it. The fragment was a thin piece about a line and a half long, one line in width at one end, half a line at the other end. The patient recovered completely, and returned to work on December 10 following." There can hardly be a doubt that the magnet saved the eye in both cases. In the first case, to have followed the sharp fragment with forceps would probably have inflicted irreparable damage, and, indeed, the body might have got out out of the way altogether. In the second case, the metal would probably, but for the magnet, have remained undetected, and have afterwards lighted up destructive inflammation. Even had it been detected, it would not have been possible, but for the magnet, to have extracted it without enlarging the wound, and that is not desirable in any part of the eye, much less in the ciliary region. By the magnet the diagnosis was established, and the extraction effected in the most delicate way.

Recent Inventions.—Professor Barrett, of Dublin, delivered an important lecture at Birmingham, on Monday night, to the members of the Midland Institute on some of Mr. Edison's recent inventions. The lecturer commenced by describing Hughes's microphone and Edison's carbon telephone. He said that for many years it was supposed that, when they made contact between two wires used for conveying an electric current, the current could not be affected by the amount of pressure between the points. This, however, had been discovered to be wrong, and it was found out that the alteration of pressure caused a slight variation in the strength of the current, more especially in semi-conductors, such as coke or granite; Hughes's microphone was based upon this fact. If an electric current were sent through the little pencils it was found that a more vigorous current was transmitted when the pencils were pressed more tightly against each other. Thus, the microphone was nothing more than the application of the principle of that variation of electric strength by variations in the points of contact or degrees of resistance the current encounters in the fragments of carbon. This had been made use of for the purpose of transmitting speech; but in using the microphone for this purpose the sounds became muffled, and an unpleasant metallic jarring was given to them. Mr. Edison had, however, got over this defect by adopting a little disc of lampblack made from the smoke of a paraffin lamp. A little disc of lampblack about the size and thickness of a sixpence was placed between two metallic discs. To the metallic discs were attached binding screws, and wires were laid to some distant receiving telephone. In front of the foremost disc was a metal plate, and attached to it a small projecting piece of metal. On speaking against the outside plate the vibration of the voice caused variations in the pressure of the little carbon disc, and thereby in the strength of the electric current, which produced alternating motions in the receiving telephone. The apparatus was so sensitive that the articulations of the voice were produced most perfectly. The lecturer illustrated the power of the carbon telephone by having some placed in connexion with wires to the Arts Club. Conversation was carried on, and by means of a funnel for increasing the sound the shouts of persons at the club could be heard over a considerable extent of the rooms, and also the notes of a cornet-player, who played "The Last Rose of Summer." The lecturer said that during the afternoon Mr. Chamberlain, M.P., was at the hall. Speaking in the middle of the hall, only slightly above his usual tone of voice, a carbon telephone on the platform received the sound and transmitted it to some friends at the club. Some of these instruments might be placed in the House of Commons, and persons at a distance would be able to hear the speeches of hon. members delivered from their usual places. The carbon telephone had led to another important discovery by Mr. Edison—namely, the microtasimeter, a thermometer of the utmost delicacy. The variations in the length of an iron bar caused by heat could be shown by the increased or decreased pressure of the end of the bar upon the disc of carbon and its influence on an electric current to the most minute degree. By means of this appliance the inventor at the last eclipse of the sun was able to observe the heat radiants by the corona of the sun. The variations in the length of the iron bar could be detected to the ten-millionth part of an inch. The phonograph, electric pen, and other of Mr. Edison's numerous inventions, were also explained. Referring to the large number of appliances which Mr. Edison has invented, Professor Barrett said that Mr. Edison's agent, Mr. Adams, had just received the following telegram relating to the electric light:—"I have just solved the problem of the sub-division of the electric light indefinitely, but it will not be shown until all the patents are secured, and then I will send a description."

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DESILVERING AND REFINING LEAD BASE BULLION BY ELECTROLYSIS.

BY N. S. KEITH, NEW YORK CITY.

I have invented a process for separating lead from all impurities, and at the same operation retaining its contents of gold, silver, antimony, copper, iron, etc., in such form as to be most readily utilised by any of the various metallurgical processes adapted to accomplish the desired object.

This is done by the agency of Force, when active in matter so arranged as to show that *manifestation of Force in action called Electricity*. Its science may be studied under the title *Electrolysis*. As but very little has been written on the electrolysis of lead, not much more information specifically relating to that metal can be found than this: The "lead tree," formed by depositing lead by means of zinc from solutions of its salts, is noted. The equivalent of lead is stated as 103·5. The formation of chromatic rings by electro-deposition of lead oxide, and the statement that its deposition as metal has received no practical application, are about all. Its electro-metallurgy is governed by the well-defined laws which govern that of the other metals so much used in the electrotyper's and electroplater's art, namely, copper, silver, nickel, and gold. Like tin, it is difficult to deposit as a reguline coating—adherent or coherent—the tendency being to deposit in a crystalline form having no uniformity of accumulation. I attempt in this a description of the various stages of the operation, from the reception of the base bullion in pigs or slabs to the final sending out of the purified lead in various shapes and fine bullion consisting of gold and silver.

The pigs of base bullion are melted in kettles, at as low temperature as practicable, and the melted metal is drawn by a spout from the bottom of the kettle so as to get metal free from dross, and cast in the form of plates by the use of a mould working mechanically. These plates are simply rectangular, measuring 4ft. by 15in., and ½ of an inch thick. They weigh 36 pounds each. They are made thus thin for two reasons. First, as it is the extent of *surface* of lead exposed to the solvent action of the liquid of the operation which determines in one particular the extent and economy of the process, the plates, if thicker, will keep an unnecessary amount of bullion in process of treatment, enhancing the cost in way of interest, &c. Second. It has been found that plates of that thickness put in the vats may remain until the lead is dissolved, without the insoluble constituents which accumulate on the surfaces impeding the operation. It may be, however, that a little thinner or thicker plates will be found more practically economical. A melter and helper are needed for this operation, to cast ten tons in ten hours.

The plates are taken by the "bagger," who fastens them on like bars by means of clamps and screws, the bars being placed across the rack. He then draws unto each plate, from the bottom up, a bag of thick twilled muslin, made so as to fit closely and cover the plate. The object of the bags will be seen further on.

The vats 1, 2, 3, 4, 5, *et seq.*, are made of boiler or tank iron, or wood, and are each 10 × 5 × 5 feet in dimensions, and are nearly filled with a solution of soluble lead-salt, acetate or chloride by preference. In each vat is suspended a number of thin sheets of metal—say copper, brass, lead, or other metal—which the solution will not affect, and placed at equal distances apart; these sheets are suspended from bars crossing the tanks. These sheets of metal are called "cathodes," and they are in direct metallic contact with the copper bar fastened along the top edge of the vat, but are electrically insulated from the like copper bar by well-known means. The copper bar is electrically insulated from the vat.

Now, the muslin-covered plates of base bullion are lifted with their bars by an overhead travelling conveyer, and placed in one of the vats, so that they may hang alternate with the *cathodes*. In this position they are called the *anodes*. The bars by which they are suspended are put in direct metallic contact with one bar, but are insulated, electrically, from the other bar. All the other vats are filled in this manner.

A dynamo-electric machine, capable of electrically depositing about 70 pounds of lead per hour in a single vat, is, by means of conductors from the positive pole, electrically connected with the *anodes* of vats 1, 2, 3, 4, placed in multiple arc. The cathodes are, as noted, resting on the vats. On the vats, 1, 2, 3, 4, conductors are fastened, and lead to the rod of the next arc of vats, 5, 6, 7, 8. Like connections are made through the whole series of vats till, reaching the final arc of the series, 45, 46, 47, and 48, the conductor is connected directly with those vats and the negative pole of the dynamo-electric machine.

All now being in place, the dynamo-electric machine is started, and immediately that motion of matter we call electricity is set up in the entire electric circuit which we have made, and we observe its effects in all parts of the circuit. First, the temperature of all parts is raised; the machine, conductors, and solution all increase in temperature in the proportions which the electrical resistances of their several parts bear to the resistance of the whole. If 12-horse power is used by the machine, then its equivalent of heat is distributed through the circuit. As the machine exposes but a small surface for radiation, it is cooled by water, ready means being provided for that purpose. As radiation of heat from the conductors, vats, and solutions is more rapid, their temperature is not unduly increased. Next, we observe that all parts of the circuit are magnetic. The anodes we shall observe continually *decreasing* in weight, and the cathodes *increasing* in weight in exactly the same amount as the decrease of the anodes. This arises from the solution of the lead of the anodes and the deposition of lead upon the cathodes. It has been said that electricity determines chemical affinity; and that statement will answer for simplicity in stating the general fact. At the anodes, lead, being the most electro-positive of their constituents, having the greatest affinity for the most electro-negative constituents of the solution, combines with them and forms a salt of lead which is soluble in the liquid, be the salt formed an oxide (*sic*), chloride, acetate, or nitrate. At the cathode the solution gives up its lead, as it is the constituent of the solution which most readily parts with its salifying acid.

What takes place in the solution, in what manner lead is transferred from the anodes to cathodes, the theories of the action and reaction, are not necessary here to discuss.

The facts are, like those belonging to copper electrolytic solutions, the same amount of lead is dissolved as is deposited, there is no decomposition of the solution nor waste, and an equivalent of lead is obtained for each equivalent of electricity. A current of electricity which will, at the same time, dissolve and deposit 31·75lb. of copper, will deposit 103·5 of lead, and so on in the proportion of the chemical equivalents of the metals.

This transfer of lead from the anodes to the cathodes continues, as long as a current of electricity is kept up, until the lead of the anodes is completely dissolved. In practice it is well to replace the anodes which are nearly dissolved by new ones, using the remaining very thin light pieces by melting and casting anew.

The lead which accumulates on the cathodes is in a crystalline form, having slight cohesion, so that it falls off into the space left below the electrodes, where it lies unaffected until cleaning-up time arrives. As the vats are not all charged at one time, the filling and cleaning-up goes on from day to day, progressively, as fast as the anodes are dissolved. About four vats a day in this plant is the number. This operation is as follows:—It is conducted by two men: by the conveyer the cathodes are raised from the vat and placed in the next preceding vat, which has just been cleaned and made ready to receive them. At the same time the solution of the vat is being withdrawn through the conduit to the cistern, whence it may be pumped to fill again the same or any other vat. The anode bags and bars are conveyed to the end near the cistern for subsequent treatment. When the solution has run out, the lead is shovelled into moulds of desired shape, and carried by the conveyer to the press. The solution is now pumped back, the cathodes from the next vat to be cleaned are placed in it, as at first, and new bagged anodes are taken, and placed as in the first filling, and the operation of transfer of lead goes on. No interruption of the work takes place other than in that vat which is being cleaned.

The filled moulds at the press have their contents compressed by hydraulic pressure so as to expel the contents of solution. The resulting cakes, bars, pigs, or other forms of pure lead are sufficiently compact and coherent to bear handling and transportation, and are thus protected from oxidation. Experiments are now being tried with this product, compressed in different degrees of hardness, to test its adaptability for corrosion in white-lead manufacture. Its porous condition insures rapid corrosion, a great *desideratum* if coupled with a quality of product which painters call "*body*." As to its purity there is no question.

The bags are removed from the exhausted anodes, turned, and rinsed in water, so as to wash off the fine powder of metallic impurities which the dissolving of the lead has left in them, and are taken to the bagger to be used again. The pieces of undissolved anodes, weighing one to three pounds to each bag, are brushed off in water and are sent to the melting-pot to be cast anew. After the powder has settled, the clear wash-water is drawn off for use again, and the muddy bottom is placed on the filters to drain and dry. The wash-water is used to replace the water evaporated from the vats, so there is no waste of solution.

This powder is an alloy of the impurities of the base bullion, say, antimony, arsenic, silver, gold, copper, and iron. It may be prepared for fusion by exposure to a red heat with access of air, which will oxidize the metals other than gold and silver, when it may be fused with soda-ash and borax; or it may be fused at once, using nitrate of soda and borax. From the slag

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thus obtained, antimony may be separated by well-known ways, and probably with profit. The other metals are not found in quantity enough to warrant their separation.

The dross which rises to the top of the bullion during the melting in the kettle is moulded into plates and is bagged, and otherwise goes through the same treatment as the more fluid portions, but in a vat used only for that purpose, as it contains a larger per cent. of other metals.

The full operation, then, may be stated more concisely :—

1st. Casting.
2d. Bagging.
3d. Filling the vats—Removing the products.
4th. Pressing the lead.
5th. Cleaning the bags.
6th. Fusion of gold and silver.

The labour is performed during daylight. All the services and attention needed at night are those of an engineer, if boiler and engine are the source of power, or a watchman in case of water-power. The expense is about as follows for ten tons each 24 hours :

Labour—2 engineers.
1 melter and helper.
1 bagger.
2 cleaners.
1 bag-washer.
1 pressman.
1 assayer, melter, and refiner.
1 general helper.

10 men at average of \$2	\$20.00
Superintendence	7.00
Fuel for melting and power	5.00
Fluxes, crucibles, &c.	5.00
Incidentals, such as bags, oil, &c.	3.00
10 tons at \$4 per ton	\$40.00

The advantages are these :—

Saving of all the lead (none lost by vaporising, oxidation, etc.).
Saving of all the silver and gold (none remaining in lead).
Saving of antimony.
Simplicity of manipulation.
Complete control of quality of products.
Cheapness.

The amount of lead dissolved and deposited in each arc of four vats is seventy pounds per hour, and the number of the series is 12, so that we get $70 \times 24 \times 12 = 20{,}160$ pounds of lead per day, for an expenditure of, say 12 horse-power.

The same amount can be done with less power, but it requires an increase in the number of the series, and also in the amount of surface and quantity of base bullion.

So that there is a point where the saving in power will be balanced by the extra expense of plant and material under treatment.

ON THE RESISTANCE OF TELEGRAPHIC ELECTRO-MAGNETS.*

By Oliver Heaviside.

1. There appears to be some uncertainty regarding the proper resistance which electro-magnets for signalling purposes should have—whether a receiving instrument should have a resistance equal to that of the remainder of the circuit, or a half, or a fifth, or some other fixed fraction thereof. Practical experience, especially with high-speed instruments, has shown that the resistances in general use are too high, and that advantage is gained by reducing the resistance of an electro-magnetic receiving instrument employing fewer windings of a thicker wire in place of more windings of a thinner, thereby reducing the self-induction as well. Ohm, as long ago as 1826, showed that the resistance of a galvanometer should equal that of the rest of the circuit in which it is placed, to obtain the maximum magnetic force. When the correction needed on account of the thickness of the insulating covering of the wire is also reckoned, then the thickness of the wire of the galvanometer should be such that the external resistance is to the resistance of the galvanometer-coil as the diameter of the covered wire is to the diameter of the wire itself (Maxwell, vol. ii. p. 321).

Now if, in telegraphic signalling, sufficient time were allowed during every signal (positive, negative, or no current) for the full effect to be produced in the circuit by the electromotive force, or for the current to entirely die away, the above result would hold good also. But such is not the case; for, by reason of electrostatic and electro-magnetic induction, the current has not time to reach its full strength during every signal. On a land-line, unless it is very long, electro-magnetic induction is the principal retarding cause; and it is this case which is here considered.

* From the *Philosophical Magazine*.

2. Let there be a simple harmonic variation of electromotive force E sin. $m\,t$, where E and m are constants, and t is the time, in a circuit resistance R and electromagnetic capacity L. The equation of the current is

$$E \sin. m t = \left(R + L\frac{d}{dt}\right)\gamma, \quad . \quad . \quad . \quad . \quad (1)$$

where γ is the current at the time t. The solution of (1) is

$$\gamma = \frac{E}{\sqrt{R^2 + L^2 m^2}} \sin. \left(m t - \tan.^{-1}\frac{m\,L}{R}\right),$$

neglecting a vanishing term. The amplitude of the current waves is thus reduced from $\frac{E}{R}$ (what it would be were there no retardation to

$$\Gamma = \frac{E}{\sqrt{R^2 + L^2 m^2}}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where Γ signifies the maximum current. Or the current is the same as if the resistance were increased in the ratio of

$$1 : \sqrt{1 + \left(\frac{L\,m}{R}\right)^2}.$$

If $L\,m$ is large compared with R, then Γ is small compared with $\frac{E}{R}$, or the diminution of current-strength is large. Let T be the time of a complete reversal. Then $m = \frac{2\pi}{T}$. With the Morse code, when $T = \frac{1}{40}$ second, or $m = 80\pi$, an automatic transmitter produces 100 words per minute, or a little more. Let $\frac{L}{R}$ be between $\frac{1}{100}$ and $\frac{1}{10}$ second, then $\frac{L\,m}{R}$ is between $\frac{8\pi}{10}$ and 8π, or (say) between 2·5 and 25; therefore the current will be reduced from 2·5 to 25 times.

On telephonic circuits, owing to the great rapidity of the reversals, the reduction in current-strength is great, and is nearly inversely proportional to the pitch of the tone, thus rendering it impossible to reproduce at the receiving end the same quality of sound as is emittted at the sending end, irrespective of mechanical or acoustical difficulties. The second partial tone of any continuous sound will be weakened twice as much as the first, the third thrice as much as the first, and so on, thus producing a general deadness or want of brilliancy.

It also appears from (2) that the resistance of the circuit becomes quite subordinate when $\frac{L\,m}{R}$ is large; and it may then be greatly increased without much weakening the current. This is remarkably evident on telephonic circuits. On automatic circuits it has sometimes been found beneficial to introduce resistance-coils at the receiving end. The irregular effects of leakage from neighbouring wires, which mutilate the proper signals, are reduced in a greater proportion than the proper signals themselves.

3. Now let R and L belong to the electromagnet alone, and R_1 and L_1 be the resistance and electromagnetic capacity of the remainder of the circuit. Then (2) becomes

$$\Gamma = \frac{E}{\sqrt{(R + R_1)^2 + m^2 (L + L_1)^2}}. \quad . \quad . \quad . \quad (3)$$

In solenoidal electromagnets, if n is the number of windings of the wire in unit of length, and the number of layers in unit of thickness, R varies as n^4. L also varies as n^4, while the magnetising force due to the unit current varies as n^2. Applying this to equation (3), if F is the magnetising force, F is a maximum, n being variable, when

$$R^2 + L^2 m^2 = R_1^2 + L_1^2 m^2, \quad . \quad . \quad . \quad . \quad (4)$$

R_1 and L_1 being considered constant, as belonging to the line. We may write (4) thus,

$$\frac{R}{R_1} = \sqrt{\frac{1 + m^2\left(\frac{L_1}{R_1}\right)^2}{1 + m^2\left(\frac{L}{R}\right)^2}}. \quad . \quad . \quad . \quad . \quad (5)$$

Now $\frac{L_1}{R_1}$ is constant for the same line-wire, whatever its length, since both L_1 and R_1 are proportional to the length of line. Also $\frac{L}{R}$ is constant for the same coil, if only the diameter of the wire

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is variable, since both L and R vary as n^4. But the time interval $\frac{L}{R}$ for the electromagnet is in general much greater than the time interval $\frac{L_1}{R_1}$ for the line-wire; whence it follows, by inspection of (5), that R must be much less than R_1 to produce the maximum magnetising force; and the higher the speed, which is proportional to m, the less should R be.

The calculation of $\frac{L_1}{R_1}$ is easy, since the line-wire is long, straight, and parallel to the earth; but the calculation of $\frac{L}{R}$ is not so easy, owing to the variety of shapes assumed by electromagnets used for telegraphic purposes, with their cores, pole-pieces, and armature, which all influence the electromagnetic capacity, though they do not influence the resistance. It is, therefore, impossible to enunciate a general law, that the resistance of an electromagnet should be such or such a fraction of the external resistance; for the result will be different, not only for every speed, but for every different construction of the electromagnet.

4. Approximate results are, however, easily obtainable in the case of a solenoidal electromagnet. Let its length be l, external radius x, internal radius y, with an iron core of radius z. Its electromagnetic capacity is

$$L = \frac{4}{3}\pi^2 l n^4 (x - y)^2 (x^2 + 2xy + 3y^2 + 24\pi\kappa z^2). \quad (6)$$

("Maxwell," vol. ii. p. 283), where κ is the coefficient of magnetisation of the core. Its resistance is

$$R = \pi \rho l n^4 (x^2 - y^2), \quad . \quad . \quad . \quad . \quad . \quad (7)$$

where ρ is the resistance of unit of length of wire of unit diameter.

Therefore

$$\frac{L}{R} = 16\,\pi^2 \frac{\kappa}{\rho} \frac{x - y}{x + y} z^2 \quad . \quad . \quad . \quad . \quad (8)$$

approximately, by leaving out $x^2 + 2xy + 3y^2$ in (6), as small in comparison with $24\pi\kappa z^2$, which is a large number, unless the core is very small. Let $\kappa = 32$; also, if the specific resistance of copper be taken at 1·7 microhm = 1700 c. g. s., then $\rho = 1700 \times \frac{4}{\pi}$, and

$$\frac{L}{R} = 2{\cdot}33 \frac{x - y}{x + y} z^2 \text{ seconds.} \quad . \quad . \quad . \quad . \quad (9)$$

5. To determine $\frac{L_1}{R_1}$ for the line-wire, Maxwell (vol. ii. p. 282) gives the coefficient of self-induction of a straight wire, the circuit being completed by a parallel wire. The same method of calculation is applicable to any number of parallel straight wires, by finding the integral

$$T = \tfrac{1}{2}\iiint H w \, dx \, dy \, dz,$$

where T is the kinetic energy of the system, and H, w are the vector-potential and the current at a point, both parallel to the axes of the wires. Thus, for n parallel straight cylindrical wires of length l, conveying currents C_1, C_2,......, of radii a_1, a_2,......, specific magnetic capacities μ_1, μ_2,......, representing the distance between the centre of two wires m and n by b_{mn} we shall have

$$\left.\begin{aligned} \frac{2T}{l} &= \tfrac{1}{2}(\mu_1 C^2_1 + \mu_2 C^2_2 + \ldots), \\ &\quad - 2\mu_0 (C^2_1 \log a_1 + C^2_2 \log a_2 + \ldots), \\ &\quad - 4\mu_0 (C_1 C_2 \log b_{12} + C_1 C_3 \log b_{13} + C_2 C_3 \log b_{23} + \ldots), \end{aligned}\right\} (10)$$

with the sole condition $C_1 + C_2 + C_3 + \ldots = 0$. Let there be only four wires, 1 and 3 for one circuit, 2 and 4 for another; then $C_3 = -C_1$, and $C_4 = -C_2$. Substituting in (10),

$$\begin{aligned} \frac{2T}{l} = C^2_1 &\left(\frac{\mu_1 + \mu_3}{2} + 2\mu_0 \log \frac{b^2_{13}}{a_1 a_3}\right) \\ + C^2_2 &\left(\frac{\mu_2 + \mu_4}{2} + 2\mu_0 \log \frac{b^2_{24}}{a_2 a_4}\right) \\ + 2\,C_1 C_2 &\times 2\mu_0 \log \frac{b_{14} b_{23}}{b_{12} b_{34}}. \quad . \quad . \quad . \quad (11) \end{aligned}$$

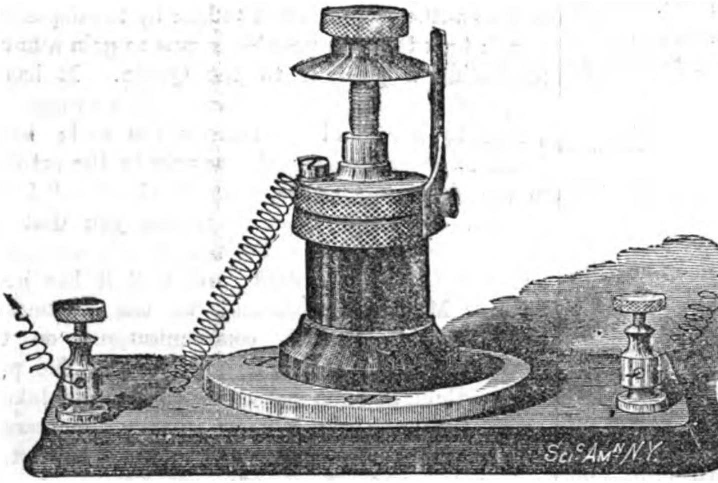
The coefficient of C^2_1 in (11) is the coefficient of self-induction per unit of length of the circuit conveying the current C_1. Similarly for C^2_2; and the co-efficient of $2\,C_1 C_2$ is the coefficient of mutual induction per unit of length of the two circuits.

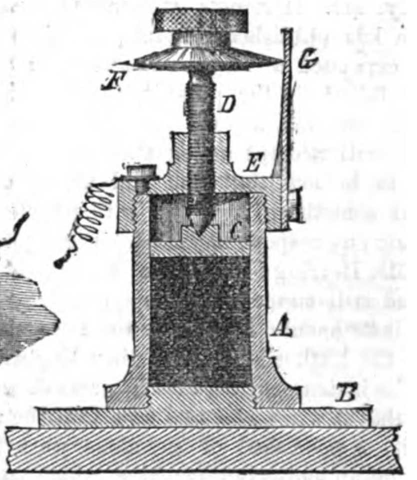
[TO BE CONTINUED.]

EDISON'S NEW CARBON RHEOSTAT.

In quadruplex telegraphy it is vital to the working of the system to perfectly balance the electrical current.

The common method of doing this is to employ a rheostat containing a great length of resistance wire, more or less of which may be thrown into or cut out of the electrical circuit by inserting or withdrawing plugs or keys. This operation often requires thirty minutes or more of time that is or might be very valuable.





To remedy this difficulty Mr. Edison has devised the instrument represented in the engraving, Fig 1 being a perspective view, and Fig. 2 a vertical section.

A hollow vulcanite cylinder A is screwed on a boss on the brass plate B. Fifty discs—cut from a piece of silk that has been saturated with sizing and well filled with fine plumbago and dried—are placed upon the boss of the plate B, and are surmounted by a plate C, having a central conical cavity in its upper surface. A pointed screw D, passes through the cap E, at the top of the cylinder A, and projects into the conical cavity in the plate C. The screw is provided with a disc F, having a knife edge periphery which extends to the scale G, and serves as an index to show the degree of compression to which the silk discs are subjected.

The instrument is placed in the circuit by connecting the cap E with one end of the battery wire, and the plate B with the other end.

The principle of the instrument is identical with that of Mr. Edison's carbon telephone. The compression of the series of discs increases conductivity; a diminution of pressure increases the resistance. Any degree of resistance within the scope of the instrument may be had by turning the screw one way or the other.

In this instrument the resistance may be varied from 400 to 6,000 ohms, and any amount of resistance may be had by increasing the number of silk discs.—*Scientific American.*

[We are indebted to the kindness of Mr. Edison for the illustrations accompanying this note.—ED. E.]

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THE ELECTRICIAN.

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NOTICE TO EDITORS.

We shall be happy to exchange with the Editors of Scientific journals who receive the first numbers of THE ELECTRICIAN.

Nous serons heureux de faire l'échange avec Messieurs les Rédacteurs des Journaux scientifiques qui recevront les premiers numéros de L'ELECTRICIAN.

Es wird uns ein Vergnügen sein mit den löblichen Redactionen der deutschen und anderen continentalen Journäle und Zeitschriften, denen die ersten Nos. des ELECTRICIAN *zu Händen kommen möchten auszutauschen.*

I Signori Editori di giornali scientifici che riceveranno i primi numeri dell' ELECTRICIAN *ci faranno cosa gradita accettando il cambio che loro offriamo.*

MR. HERRING AND THE POSTAL TELEGRAPH DEPARTMENT.

In a recent number we published and referred to a most remarkable letter of Mr. R. Herring, which originally appeared in the *Journal of the Society of Arts*, of which society Mr. Herring is a member, and holds the position of Examiner in some of the examinations. We stated that the charges contained in this letter were so grave that they could not be discussed from *ex parte* statements. However, we find that, if they are to be discussed at all, it must be with only Mr. Herring's statements before us. That gentleman has published several pamphlets on the subject, and has expended a large amount of money, as well as time and talent, in the pursuit, thus far in vain, of fair treatment. So far as we can, in the compass of this article, we will attempt a fair statement of the case, and we are fain to believe that one and all of our readers will agree that something is wrong with a system that connives at shielding any responsible head. Eight years ago, that is, in 1870, Mr. Herring brought an instrument, which he supposed and still supposes to be an improvement upon the printing instruments in use by the Department before the notice of the authorities. The then Engineer-in-chief condemned the instrument because it printed, and informed the inventor that it was a *sine quâ non* that the signs should be embossed. A good deal of ingenious work resulted in the designing of an embossing machine, which an inspector, sent on the 30th January, 1871, condemned because it did not print. Thus the first experiences of our inventor were not altogether satisfactory, nor, it will be seen, were his after experiences. We must point out that some of the remarks printed in Mr. Herring's pamphlet, and criticised by him as adverse to his interests, may not have been uttered or written in the spirit he claims for them. Thus the Engineer-in-chief is stated to have written, "Of course, even though there is no doubt Mr. Herring's invention is useless, I will have it seen." And again, "We might allow Mr. Herring to try his instrument on a line where it would no doubt die a natural death." We are rather inclined to think such sentences quite innocent of any covert intention. The latter does not necessarily refer to the putting the intrument on such a difficult line that it must break down, but may have been written by the Engineer when thinking there was not much in Mr. Herring's instrument, and that, if used on any line, it would soon show its defects, and be put aside as worthless. It should be remarked that the Engineer had not seen the instrument, and, therefore, should not have expressed an opinion. Mr. Herring, looking at the sentences from his point of view, and in connection with the whole treatment he received, looks upon them as showing a preconceived opinion and a predetermined opposition. However, the Secretary of the Department wrote that the system "was much superior to the numerous methods which had been brought forward from time to time during the last twenty years," and proposed that the instrument should be fairly tried by Professor Sir William Thomson and Professor Fleming Jenkin. It is needless to enter into the details of what immediately followed. A preliminary report was signed by Professor Fleming Jenkin. The instrument was tried by the gentlemen referred to, but the trial was of such a character, and so unsatisfactory, that Mr. Herring protested against it, and the Secretary of the Department admitted that a further and complete trial, with additional apparatus, as suggested by Professor Jenkin, was necessary. However, without any such further trial taking place, a final report was made, and the question, so far as the Department was concerned, shelved. But Mr. Herring was not the man to tamely submit to such summary procedure. He protested against the use of the term "final" when it had been admitted that no satisfactory trial had been made. He criticised the so-called final report, and submitted his criticism to the authorities. He wrote to the Postmaster General. He managed to have his case brought before the notice of Parliament, and papers to be printed "by command." According to Mr. Herring, very one-sided the papers are, and with important parts and important papers even entirely omitted. He could get no redress—buffeted from one official to the other—told that this man had no authority—referred to him by the department—he at length took the best possible means to gain a fair hearing by presenting a petition to the Queen. It has long been supposed that, if an Englishman suffers wrong, there is some means to be found to remedy the evil; but this idea seems to be erroneous. An answer to the petition, couched in the following words, was received:—"I am directed by Mr. Secretary Cross to inform you that he has laid before the Queen the Petition which accompanied your letter of the 19th instant; and that it has been referred, by Her Majesty's command, to the Postmaster-General, to whom all further communications on the subject to which it relates should be addressed." The petitioner, of course, thought some notice would now be taken of his request; but Lord John Manners, through his secretary, simply acknowledged a letter sent to him on the subject. This treatment induced Mr. Herring to present a second petition, dated 4th February, 1878, stating that no notice had been taken of Her Majesty's commands. To this petition we do not see that any answer has been received.

The case before us, then, can be clearly summarised. A gentleman submits an invention to the authorities. An admittedly untrustworthy trial is made, upon which a report is founded. The promised further trial is never made, nor can the

authorities be induced to make it. The submission of the case to Parliament brings no result, nor does a petition to the Queen. Now, the instrument is either better or worse than the instruments at present in use. If the latter, the trial should be such that there cannot be any dispute in the case; if the former, it is in the interest of the public that the instrument should be used. The question of what apparatus shall or shall not be used is one that must evidently be settled by the authorities, but behind this there is a still greater question, viz., shall the public interest be subverted by the will of this or that individual? A public department is instituted for the welfare of the public, and, like Cæsar's wife, should be above suspicion. Any one who studies the case of Mr. Herring must conclude that the Telegraph Department has not been conducted in a manner calculated to win the sympathies of inventors, and to invite them to use their talents in devising instruments for the better performance of the work in hand, and submitting the same for fair trial. The general idea is that the fair trial required cannot be obtained. The final report above mentioned condemns the instrument, but the report is based upon trials not satisfactory. Other eminent electricians give an opinion that the invention is very valuable, and would save public money. It seems to us that the authorities should, for their own sake, arrange for a meeting of the authors of the rival reports, as is suggested by Mr. Herring. There certainly must be good ground for such procedure when Mr. Latimer Clark says: "That the transmitting slip for the alphabet has only eighty-two perforations, and measures only $10\frac{1}{2}$ inches, against 164 and 14, respectively, on the Post Office system; that the alphabet receiving slip measures less than 5 inches, against 15 inches by the system now in use at the Post Office; that, instead of the signals failing, as Professor Jenkin has stated, Mr. Latimer Clark finds the instrument capable of recording 1,600 perfect signals in a minute, and that this has been actually accomplished by an instrument which has been subjected to harsh experiments for several years, and was not made by a first-rate maker. Mr. Latimer Clark also affirms that the system would not only surpass the system in use at the Post Office, both in speed and accuracy, but it would save nearly 75 per cent. in the cost of paper."

We can quite understand that the present officials hesitate to reconsider the decisions of their predecessors, or to carry on a discussion upon actions which occurred before their advent to power. Still, there are cases where something of the kind is necessary. Is not this an indictment of sufficient importance to set aside the considerations—courtesies, if you like—shown in petty minor matters. "The Government Telegraph Department," says Mr. Herring, "after the fullest consideration, promised that there should be a trial of my system. It invited me to prepare for such a trial. It induced me to engage scientific gentlemen to represent me at such trial. It arranged and signed terms of reference. It promised to adopt my system if the trial were satisfactory, and it obtained possession of my instruments under a written promise to complete the trial. Without any explanation, however, the Department has broken the promises which it made, and has thus caused me to expend my money and my time uselessly. It makes no offer to reimburse me, and treats my complaint with contempt."

We should like to hear the experience of other inventors in connection with the Department, in order to know whether the case of Mr. Herring is exceptional, or whether the treatment is of the ordinary kind.

THE EFFECT OF METALLIC DIAPHRAGMS ON THE DISTRIBUTION OF A CURRENT IN AN ELECTROLYTE.

In November, 1876, Dr. Guthrie showed me a round dish containing a saturated solution of sulphate of copper and six disconnected platinum plates arranged in series, the end ones being smaller than the others and connected to a battery of five Grove cells (Fig. 1). Call the outer plates or electrodes A and B, and number the four middle ones from A to B; A being the positive or platinode.

Gas (oxygen) was seen rising from A, and copper was being deposited on B; a feeble deposit of copper was forming in the middle of Plate 1 on the side facing A, and about the size of A; and a still more feeble deposit was seen in slight patches on the A face of 4, near the edges. Nothing whatever on Nos. 2 and 3.

To explain this, and to consider more generally what the effect of such metallic diaphragms would be in different cases, consider the electrodes A and B as copper rods extending the whole depth of the liquid sulphate of copper. The conditions of the flow will then be precisely the same as those in a plane circular disc, all horizontal cross sections being alike. Further, for simplicity, let A and B touch the side of the circular disc, and let their cross section (if not very small) be lenticular, or contained between two intersecting circles, such that one of the circles coincides

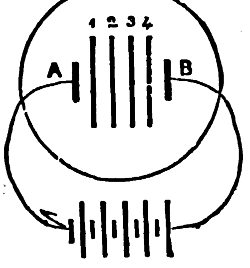

Fig 1.

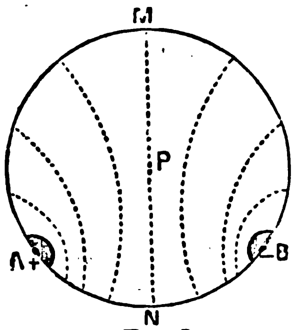

Fig 2.

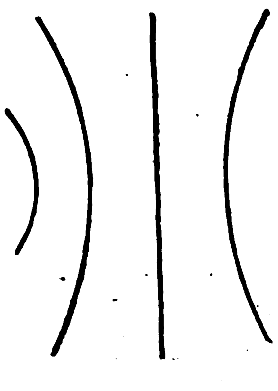

Fig 3.

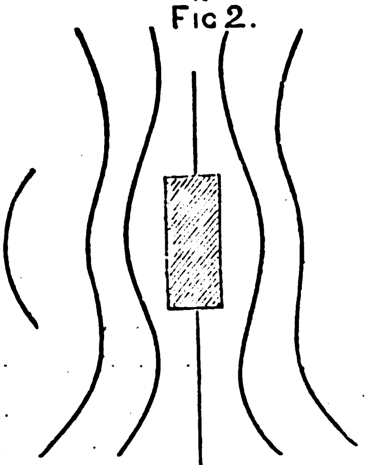

Fig 4.

with the edge of the disc and the other cuts it at right angles (Fig. 2). Then everything about the flow is completely known. The stream-lines are the system of coaxal circles which all intersect in the same points A and B; the equipotential lines are the orthogonal coaxal system, whose general aspect is shown in Fig. 2. They are each characterised by the equation $\frac{AP}{BP}$ = constant; the constants for successive lines going in geometrical progression. The letters A and B refer now to two points on the edge of the disc and in the line joining the centres of the electrode circles.

Now take an infinitely thin plane film of copper and place it in the middle line M N as a partition. No disturbance will be produced, whether the film extend from M to N or only a little way. The only effect will be a gradual creeping of the film towards A by reason of a deposit of copper on one side, and a removal of copper from the other. But the film would not remain straight as it so progressed; it would become concave towards B, for the amount of copper deposited and removed at any point P would be directly as the strength of the current at that point, *i. e.*, inversely as the product of the distances from A and B; or, as these distances are practically equal, the deposit is proportional to $\frac{1}{AP^2}$. Of course, when the film becomes curved, it introduces some disturbance. See later.

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Next, suppose that the copper diaphragm is not infinitely thin, but that it displaces a little liquid. Then, since it is infinitely conducting, compared with the liquid, its effect would be slightly to decrease the resistance opposed to the current; and, if it extended as a complete partition from M to N, it would have no other effect. But, if it only extended a short distance, it would disturb the flow somewhat, the stream lines near it crowding up together in order to pass through it; or, as it may be otherwise expressed, it would cause the equipotential surfaces touching its two faces to coincide. The shape of the equipotential lines near it would be altered from Fig. 3 to Fig. 4.

Next, suppose the film infinitely thin again, but, instead of being copper, let it be something else—as platinum; then an electro-motive force will be generated between its surfaces, from the tendency to deposit copper on the one side and oxygen on the other. Call this E.M.F. ϵ; the whole E.M.F. of the battery, E; the resistance from A to B, r; the resistance of the rest of the circuit, including battery, R.

First, let the film extend from M to N; then, in order that a current may pass at all, the difference of potential between A and B must exceed ϵ. So, if the total E.M.F. of the battery E does not exceed ϵ, no current can pass (except that which sets up the polarisation). But, if it does exceed ϵ, then a current must pass, and the difference of potential between A and B will be $\frac{E\,r + \epsilon\,R}{R + r}$ instead of $\frac{E\,r}{R + r}$, its value before the diaphragm was inserted. Call this difference of potential V. If the partition is *not* infinitely thin, but displaces a film of liquid of resistance ρ, we must write $r - \rho$ here instead of r.

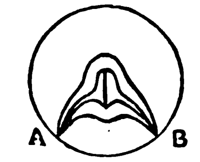

Fig 5.

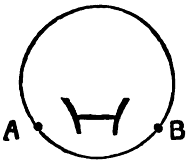

Fig 6.

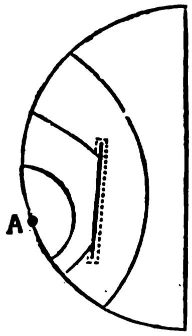

Fig 7.

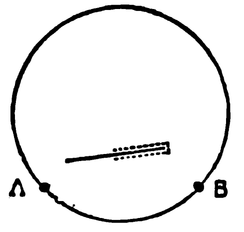

Fig 8.

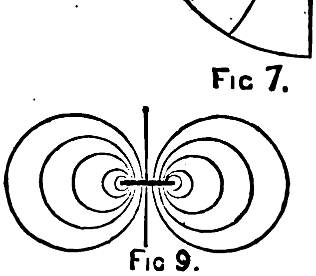

Fig 9.

Next suppose the platinum diaphragm to extend only a little way. If infinitely thin it does not directly affect the resistance of the liquid, but it sets up the opposition E.M.F. ϵ to any current passing through it. If ϵ is greater than E, all the current goes round it as if it were a glass obstacle. If ϵ is greater than the difference of potential V between A and B, the same occurs; but, if the plate be tolerably large, the resistance of the choked path now open to the current will be so much greater than before the introduction of the diaphragm that V will rise and may surpass ϵ. In that case, a small current will go through the platinum, the electromotive force driving it being $V - \epsilon$, whereas everywhere else it is V. We have, in fact, a sort of *waterfall* over the plate. The lines of flow near the plate will be distorted somewhat as in Fig. 5.

Denoting the resistance of the portion of the liquid (A, plate, B) enclosed between the two stream lines which pass the edges of the plate by r_1, and the resistance of the whole dish of liquid *with the plate inserted* by r; the quantity of electricity flowing per second through the plate is $\frac{V - \epsilon}{r_1}$, while the quantity flowing round the plate through the rest of the liquid is $V \cdot \frac{r_1 - r}{r\,r_1}$

If, however, instead of one such plate, there are two in different positions, and connected by a wire (Fig. 6), then the resistance through the metal will be so much smaller than through the liquid that a considerable current will flow *viâ* the plates and wire, even though the E.M.F. driving it is less. Copper will therefore be plentifully deposited, though not uniformly, on the plate near A, while oxygen will rise from the other plate.

Hitherto we have supposed the plate, when thin, to be placed so as to coincide with a natural equipotential surface. (We have especially supposed the plate to be plane and in the middle line, but the results will be the same if it is anywhere else, provided it is curved and arranged so as to coincide with the previous equipotential surface at that place.)

If, however, it does *not* so coincide (suppose, for instance, a flat plate arranged nearer A than B), then, although infinitely thin, it will displace the equipotential surfaces a little, because itself is necessarily of a practically constant potential.

An equivalent of copper will be deposited on the side near A for every unit of electricity passing through it, and, on the other side, an equivalent of oxygen; but, though the same quantity of electricity enters as leaves the plate, yet, the leaving side being further from the negative pole than the entering side is from the positive, more surface must be allowed to it; in other words, it will encroach on the side facing A. The entering portion of the plate is part of one side; the leaving portion is the rest of it and all the other. Hence oxygen appears with varying intensity all over the portion of the plate dotted in Fig. 7, while copper is only deposited about the middle of the side near A; this effect being the more marked as the distances from A and B are more unequal.

If the current were reversed, of course copper would be deposited over the dotted part.

An exaggerated case would be that of Fig. 8.

In Dr. Guthrie's experiment the difference of potential between A and B seems just to have exceeded twice the opposition force ϵ set up between copper and oxygen; consequently, some of the current went through plates 1 and 4, the middle of 1 receiving copper, and the edges of 4. But 2 and 3 took no part in the action, and acted as if they were insulators; for 1 and 4 were practically the electrodes to them, and between 1 and 4 the difference of potential was very small. If, however, 2 and 3 had been connected by a wire, the advantage from decrease of resistance might have overbalanced the disadvantage of opposition E.M.F., and some current would, probably, have then gone through these plates also.

The actual stream and equipotential lines might be drawn for many of these cases if the lines produced by a plate alone with its surfaces at different potentials were known. These lines are rather remarkable. Throw one of the double plates of a Volta's pile (zinc and copper soldered back to back) into the sea. You have then a representation of an infinitely thin plate in an infinite medium, with its two faces at constantly different potentials. The lines of flow will be the same as those of a stationary vortex ring, and they are drawn in Maxwell's "Electricity," Vol. II., Plate xviii., as the lines of magnetic force due to a circular current. Fig. 9 gives a rough indication of them.

Hence, if an electric current is a current of ether (Edlund, &c.), you have only to imagine a centre of force (Boscovitch, Faraday, &c.) consisting of an infinitesimal disk with its faces at different potentials, and you would immediately get an ether-vortex, or a Thomsonian atom of matter, if only an electric current possessed momentum (which it does not); in other words, if only a positive electric current could be generated by itself without its accompanying equal negative one. OLIVER J. LODGE.

University College, London.

MR. EDISON AND THE ELECTRIC LIGHT.

The following description of Mr. Edison's alleged invention is taken from the *New York Sun*:—

"Mr. Edison says that he has discovered how to make electricity a cheap and practicable substitute for illuminating gas. Many scientific men have worked assiduously in that direction, but with little success. A powerful electric light was the result of these experiments, but the problem of its division into many small lights was a puzzler. Gramme, Siemens, Brush, Wallace, and others, produced at most ten lights from a single machine, but a single one of them was found to be impracticable for lighting aught save large foundries, mills, and workshops. It has been reserved for Mr. Edison to solve the difficult problem desired.* This, he says, he has done within a few days. His experience with the telephone, however, has taught him to be cautious, and he is exerting himself to perfect the new scientific marvel, which, he says, will make the use of gas for illumination a thing of the past.

"While on a visit to William Wallace, the electrical machine manufacturer in Ansonia, Connecticut, he was shown the lately perfected dynamo-electric machine for transmitting power by electricity. When power is applied to this machine it will not

* Mr. Edison is not the first to discover a simple mode of subdivision. The problem had been previously solved.—ED. E.

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only reproduce it, but will turn it into light. Although said by Edison to be more powerful than any other machine of the kind known, it will divide the light of the electricity produced into but ten separate lights. These being equal in power to 4,000 candles, their impracticability for general purposes is apparent. Each of these lights is in a substantial metal frame, capable of holding in a horizontal position two carbon plates, each 12in. long, 2½in. wide, and ½in. thick. The upper and lower parts of the frame are insulated from each other, and one of the conducting wires is connected with each carbon. In the centre, and above the upper carbon, is an electro-magnet in the circuit, with an armature, by means of which the upper carbon is separated from the lower as far as desired. Wires from the source of electricity are placed in the binding posts. The carbons being together, the circuit is closed, the electro-magnet acts, raising and lowering the upper carbon enough to give a bright light. The light moves towards the opposite end from which it starts, then changes and goes back, always moving towards the place where the carbons are nearest together. If from any cause the light goes out, the circuit is broken, and the electric magnet ceases to act. Instantly the upper magnet falls, the circuit is closed, it relights, and separates the carbon again.

"Edison, on returning home after his visit to Ansonia, studied and experimented with electric lights. On Friday last his efforts were crowned with success, and the project that has filled the minds of many scientific men for years was developed.

"'I have it now!' he said, on Saturday, while vigorously turning the handle of a Ritchie inductive coil in his laboratory at Menlo Park; 'and, singularly enough, I have obtained it through an entirely different process than that from which scientific men have ever sought to secure it. They have all been working in the same groove, and when it is known how I have accomplished my object everybody will wonder why they have never thought of it, it is so simple. When ten lights have been produced by a single electric machine it has been thought to be a great triumph of scientific skill. With the process I have just discovered I can produce 1,000—aye, 10,000—from one machine; indeed, the number may be said to be infinite. When the brilliancy and cheapness of the lights are made known to the public—which will be in a few weeks, or just as soon as I can thoroughly protect the process—illumination by carburetted hydrogen gas will be discarded. With fifteen or twenty of these dynamo-electric machines recently perfected by Mr. Wallace I can light the entire lower part of New York city, using a 500-horse power engine. I purpose to establish one of these light centres in Nassau-street, whence wires can be run up town as far as the Cooper Institute, down to the Battery, and across to both rivers. These wires must be insulated, and laid in the ground in the same manner as gas pipes. I also propose to utilise the gas burners and chandeliers now in use. In each house I can place a light meter, whence these wires will pass through the house, tapping small metallic contrivances that may be placed over each burner; then housekeepers may turn off their gas and send the meters back to the companies whence they came. Whenever it is desired to light a jet it will only be necessary to touch a little spring near it. No matches are required.

"'Again, the same wire that brings the light to you,' Mr. Edison continued, 'will also bring power and heat. With the power you can run an elevator, a sewing machine, or any other mechanical contrivance that requires a motor, and by means of the heat you may cook your food. To utilise the heat, it will only be necessary to have the ovens or stoves properly arranged for its reception. This can be done at trifling cost. The dynamo-electric machine, called a telemachon, and which has already been described, may be run by water or steam power at a distance. When used in a large city the machine would of necessity be run by steam power. I have computed the relative cost of the light, power, and heat generated by the electricity transmitted to the telemachon to be but a fraction of the cost where obtained in the ordinary way. By a battery or steam power it is 46 times cheaper, and by water power probably 95 per cent. cheaper.'

"It has been computed that by Edison's process the same amount of light that is given by 1,000 cubic feet of the carburetted hydrogen gas now used in this way, and for which from $2·50 to $3 is paid, may be obtained for from 12 to 15 cents. Edison will soon give a public exhibition of his new invention."

ERRATA.—In Professor W. E. Ayrton's article on "Duplex Transmission," which appeared in our last week's issue, in page 235, second column, line 7, for "*amateur*" read "*armature*"; line 13, for "*k*" read "*b*"; line 15, for "line to battery *e*" read "line battery *e*"; line 27, after "used" insert the words "the language of."

ELECTRIC LIGHTING.*

SIR: It is in France that the system of electric lighting has been most fully developed, and there alone has it been carried out on a large scale and under conditions in which its cost should be ascertained with considerable precision. It is, therefore, with interest that I have read in the newly-issued volume of the Proceedings of the Institution of Mechanical Engineers a paper on this subject by M. Hippolyte Fontaine, from which I have copied the following extract for insertion in your columns, if you are able to afford it space.

Before appending the extract I should like, as one who has closely observed the progress of electric lighting both in France and at home during the past twelve months, to offer an observation or two upon the subject. It appears to me that all estimates of the cost of electric lighting, based upon the apparatus in use before the introduction of M. Jablochkoff's improvements, must be entirely fallacious; because, before the date of those improvements, not only was the electric lamp or regulator an expensive instrument, but it required a separate machine for working each light, whereas M. Jablochkoff's candles, each costing but a trifle, can be burnt a dozen or more at a time in a single machine. This advantage of securing numerous lights in one machine, each light being produced by extremely simple mechanical means, is also a characteristic of M. Rapieff's inventions, which are, in my opinion, improvements in some very important particulars upon the Jablochkoff candle, simple and beautiful as that invention undoubtedly is. It surely must be upon the working of these modern systems of electric lighting (the simplicity and cheapness of which are far beyond anything that was imagined until quite recently) that the cost of electric lighting as a competitor with gas must be based. I am unable, although having much to do with the development of M. Rapieff's improvements, to give just at present the exact cost of lighting under his system; but its cost is undoubtedly very small in comparison with that of the old systems, and certainly very much below the cost of gas for equal amounts of light.

But there are reasons why electric lighting should come into very large use apart from the question of cost. There are, for example, many purposes for which electric light is so much more suitable than gas that the question of cost becomes one of minor importance. Picture galleries, for instance, present no comparison as regards truth of colour when lighted by gas and when lighted electrically. Fish markets, again (because of the true colours of fish being visible in electric light), would be advantageously lighted by electricity, even at a great increase of cost, supposing that to be necessary. Moreover, to my mind, the superiority of the electric light over that of gas for the lighting of public places and manufacturing establishments is so great that, even if the electric light were less economical than gas, it could hardly be doubted, after the displays in Paris and at Mr. Hollingshead's theatre in the Strand, that it would, nevertheless, be largely applied, with little further delay, to mills, manufactories, railway stations, docks, shipyards, warehouses, printing offices, markets, mines, public buildings, bridges, squares, thoroughfare crossings, &c. It will not be on account of nice distinctions, or even of marked differences as regards cost, that the public will consent to be deprived of the power and brilliance of electric light in such places as I have just indicated.

The applications of electric lighting in this country have as yet been so rare that but few persons can speak authoritatively as to the exact cost when the electric light is applied under the best of modern systems, and it is for this reason that you will, I hope, consider the enclosed extract deserving of a place in your columns.

I have the honour to be, Sir, your obedient servant,

October 7. E. J. REED.

"M. Ernest Manchon, proprietor of a cloth factory at Rouen, has lighted by electricity one of his workshops, formerly lighted by gas. The means are thus afforded for making a complete comparison of the two systems. The shop in question is rectangular; it is 16½ft. high, 78¾ft. wide, and 138ft. long, covering an area of 11,000 square feet. It contains 160 looms, which had been very imperfectly lighted by 160 large gas-burners, by each of which 5¼ cubic feet of gas was consumed per hour. These 160 burners have been replaced by six Gramme machines and six lamps, from which the light is projected on the roof, yielding a uniform light all over the shed, which is entirely satisfactory. Before the introduction of the new light the joists stood out from the ceiling; but M. Manchon, without hesitation, incurred the expense of a new ceiling, on which he may now congratulate himself. After five months' working with the new method of light-

* All information on this subject being important, we have given Mr. Reed's letter as it appeared first in *The Times*.

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ing, the following are the results of M. Manchon's calculations, showing the pecuniary benefit which he has derived from it:—

"ELECTRIC LIGHT.—FIRST COST:—

	£	s.	d.
1. Roof—Carpentry	£156	10	0
2. „ Painting	49	19	2¼
3. „ Workmen's time in fixing	5	0	0
4. „ Wood	2	6	0
5. Cost of five screens	5	12	0
6. Cloth for the same	1	8	0
7. Enclosure for the machines, carpentry, and glazing	8	9	6¼
8. Enclosure for the machines, zinc edging at bottom	0	12	7¼
9. Six Gramme machines, six lamps, and conductor	588	0	0
10. Shafting	57	17	0
11. Driving belts — for transmitting the power, 690ft.; for the machines, 230ft.	29	9	9½
12. Framing for the shafting	3	4	2½
13. Carriage and sundry expenses	4	0	0
	£912	8	4

"WORKING COST OF THE ELECTRIC LIGHT:—

	Per Year. 660 hours. £	s.	d.		Per Hour. s.	d.
Interest 6 per cent., depreciation 6 per cent., together 12 per cent., on 912*l*. 8s. 4d.	109	9	9½	...	3	3½
Driving power, hire	30	0	0	...	0	10¾
Carbons, 27in. per hour, at 6·53d. per foot (waste included)	40	14	8½	...	1	2¾
Superintendence and maintenance of the machines	13	4	0	...	0	4¾
Lubricating oil, 66lb.	1	13	7¼	...	0	0½
Total	£195	2	1¼	...	5	10¼

"GAS LIGHTING.—FIRST COST:—

100 burners, at 1*l*. 11*s*. 8*d*. £253 6 8

"WORKING COST FOR GAS LIGHTING:—

	Per Year. 660 hours. £	*s*.	*d*.		Per Hour. *s*.	*d*.
Interest and depreciation, 12 per cent., on 253*l*. 6*s* 8*d*.	30	8	0	...	0	11
Consumption of gas, at 7*s*. 2¼*d*. per 1,000 cubic feet	209	10	8½	...	6	3½
Repairs and maintenance of the fittings ...	8	0	0	...	0	2¾
Glass shades	4	0	0	...	0	1½
Total	£251	18	8½	...	7	6¾

"From these comparative statements it appears that the economy realised by electricity upon the cost for gas is as follows:—Annual saving, 56*l*. 16*s*. 6*d*.; saving per hour, 1*s*. 8½*d*.; saving per cent., 22·6. M. Manchon's figures are given just as he gave them; but it may be remarked that 15-horse power, the driving power required, scarcely consumes more than 55lbs. of coal per hour, costing about 4½*d*. It was, however, a matter of great interest to learn the cost of electric lighting with hired driving power.

"M. Delahaye, in a report to the Industrial Society of Rouen, referring to the lighting by electricity in M. Manchon's works, says:—

"'On entering M. Manchon's factory one is favourably impressed by a striking sense of intense brightness, due even more to the nearly entire suppression of shadows than to the brightness of the light which pervades the shop. The workwomen are very well pleased with the light obtained. The foremen, who are, no doubt, best able to form a comparison between the two lights, since they never quit the building, do not hesitate to declare that the electric light is much superior to the gas light, and that the women, like themselves, are much less fatigued after the long hours, by reason of the absence of the heat radiated from the gas reflectors which were immediately over their heads. M. Manchon has also pointed out to me a considerable advantage in the new light, due to the well-known property of the electric light of not altering even the most delicate shades of colour; the errors formerly fallen into by the workmen in renewing broken threads, or in refilling the shuttles, are thus prevented. The quality of the product is, in consequence, sensibly improved.'

"Satisfied with the success of the application of the electric light, M. Manchon has decided to extend it, in the course of next autumn, to a shop 183½ft. by 46ft., containing, like the first-mentioned shop, 160 looms."

DAMAGE BY FIRE TO A CABLE.—The cable across the Forth, belonging to the Post Office, was recently damaged by some boys making a fire on the beach immediately over the cable.

CORRESPONDENCE.

TELEGRAPHIC EDUCATION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Having been connected with the School of Submarine and Military Telegraphy and Technical Instruction Company (Limited) for some years, you will, perhaps, allow me to state that all the requirements pointed out by you (p. 234) are fulfilled in the arrangements made for the efficient instruction of candidates for the Telegraph Service at this institution.

The instruments you mention are all in daily use, and the fact that pupils are efficient as manipulators, and fully merit the certificates granted them on leaving the school, is shown by the testimony of W. T. Ansell, Esq., traffic superintendent of the Eastern Telegraph Company.

For many years past the artificial cables spoken of in your article have been in constant use, and the theoretical instruction is entrusted to a gentleman whose contributions to your own columns would almost suffice to show that he is possessed of the requisite qualifications. If any other proof be needed of the efficiency of the arrangements made for telegraphic education, it is to be found in the testimonials of such authorities as Sir William Thomson, F.R.S., Cromwell F. Varley, Esq., C.E., F.R.S., H. Saunders, Esq., M.S.T.E., &c., who have inspected the school and pronounced themselves thoroughly satisfied with the system pursued.—I am, Sir, yours truly, W. N. TIDDY.

9th October, 1878.

THE VOLT AS A UNIT OF WORK.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: On p. 224 of *The Electrician* there is an interesting paper on some Electro-metallurgical Relations of Lead, by Mr. Keith, of New York, which is a development of some principles explained in my "Electricity, its Theory, Sources, and Applications." I must take the responsibility of the statement objected to in an editorial note, that "water is not an electrolyte;" for, although the same has been maintained by others, I have given a reason for this. That reason is that "a true electrolyte is one which will decompose under an electro-motive force equivalent to the chemical affinity which holds together the two ions of which it consists." This chemical affinity itself is measurable by the heat of combination, or by the electro-motive force the combination can develope. If, then, water were an electrolyte proper, it would decompose under a force of 1·5 volt, whereas it is doubtful if pure water is not as good a dielectric as gutta percha.

But my present object is the other editorial note: "The volt, being a unit of force, cannot possibly be measured in foot-pounds—that is, by the unit of work." That is so; and yet the volt does, none the less, furnish us with the very best of all units of work, one universally applicable to all forms of force, a practical measure of the correlations of energy. To this end, however, we must use the volt as we do gravity, and unite it to other measures. The volt, acting in one ohm resistance,* gives us a measure of *work* analogous to the foot pound. Combine with this a value based upon the atomic system of nature, and we have a perfect unit of work. Such a unit, which is the 4,768 foot pounds mentioned by Mr. Keith, is used in my book under the name of "equi-volt," because it combines the force of the volt, in one ohm resistance, with chemical work representing one equivalent of action measured in grains, or equal to one grain of hydrogen.

I used this value because I had been in the habit of working on a decimal grain system of weights, and with a measure of current doing that work in ten hours, a veber current being equal to 5·68 such measures. But, of course, a gramme or decigramme weight is the right thing, and the latter has often been used as a current measure by Continental writers, as Smee used the same grain system I have employed, but only as a measure of quantity rather than of current.

The beauty of this equivolt is that, given an electromotive force, we know exactly the calorific value, or its mechanical equivalent, of the chemical actions producing that force; and, further, as I said, p. 219 of my work:—"The principle is to express all the different forces in a single unit, to connect that unit with the atomic and equivalent constitution of matter used by Nature, and to make the unit itself one which is readily capable of actual measurement and experiment." Such a unit has obvious advantages over the kilogramme metre, and foot ton, and all the other isolated units we employ. It is also, for large and practical work, what the absolute metre-gramme second unit is for pure mathematical operations, with the further advantage that it is natural, while the latter is arbitrary.

J. T. SPRAGUE.

* This is the B. A. unit of work or the "Joulad."—ED. E.

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THE ELECTRIC LIGHT AND THE GAS COMPANIES.

At the half-yearly meeting of the Surrey Consumers' Gas Company, held on the 4th inst., Mr. B. Duvall, the chairman, presided, and in moving the adoption of the report, after congratulating the shareholders on the results of the half year's working, said he had expected to see a much larger attendance, as there had been so much talk about the electric light. He was not going much into this matter, but he had no doubt their engineer would be able to answer any question relative to it. It was a startling fact when a new thing cropped up like this light that every one became scared and frightened. He was not going to "run it down;" he believed, indeed, that it was a very good thing, but he did not believe it would ever supersede gas in a commercial point of view. He was told, too, that in Paris they lighted the principal streets till midnight, and that they then lighted gas. What was that for? Simply because the electric light was so expensive—nearly ten times the cost of gas in England at the present time. It was a matter which required attention, however, and, as he had said, he would not "run it down." It was a great scheme, and something might come of it some day, but as long as he lived he should not be afraid to hold his shares, and he was approaching the largest shareholder — if he were not the largest shareholder— in the company. He was not to be scared by the electric light.—Mr. Pocock, in seconding the motion, also observed that he was not afraid of the electric light, but that it would be carried out as of public utility he was certain, and he thought that in three months they would see the whole of the Thames Embankment lighted with it. That was an experiment now being brought about, and would, he believed, be carried out. Mr. Keith, the engineer to the Metropolitan Board of Works, would make his report on Monday, and, from what that gentleman had told him that morning in a conversation with him, he was going to recommend that it be tried. He (the speaker) had seen it this year in Paris, and there, no doubt, it was a very great success. As the chairman said, the expense was enormous, but still there was ten times the amount of light for the money. As far as public buildings and squares were concerned, there was, no doubt, he said, that this light would be entertained, but he urged them as shareholders not to be alarmed. Electricity would never cook. Gas was now being extensively used in our houses for cooking purposes. For the last five years he had cooked by gas, and he found it more economical, and much more cleanly than cooking by coal. The use of gas for such purposes, he felt confident, would continue and increase, and he did not believe that the electric light would ever altogether supersede gas. He believed that the light would become of a public nature, but he hoped the shareholders would not be frightened into selling their shares at ruinous prices, "because the electric light happened to be seen in the Strand of a night."—Mr. Storr said he did not believe a word in the electric light; but the way to meet it was to cheapen the price of gas, and thus "take the bull by the horns." If they did this they might, he said, laugh at the electric light. That it would never come into our households he was quite certain, for one could not cook by it or light up rooms. As long as coal could be got, gas would be made, and he had no doubt would supersede the electric light.—Messrs. Leyton and May had no fear of the electric light, and the latter gentleman also spoke of the many purposes to which gas could be applied, and of its facility in use. Any quantity, small or large, could be used, and it could be left unattended for three weeks, or, for that matter, for three months, whereas in the case of the electric light, there was, he said, no modification, and it could remain lighted for a comparatively small period only. It also required constant attendance.—Mr. Finlay, the engineer of the company, said the directors were quite alive to the importance of reducing the price of gas, but there were many exceptional circumstances against the company. It had been said that amalgamation would do away with this, and, no doubt, the larger the concern the smaller, relatively, were the expenses; but there were so many difficulties in the way of amalgamation, so many interests had to be consulted.—Mr. James, one of the directors, observed that at the moment there was an agreement for amalgamation pending between the Chartered, the South Metropolitan, the Phœnix, and the Surrey Consumers gas companies. He understood that the matter was only suspended till the Chartered Company had been able to ascertain what their position was.—At the request of a shareholder, Mr. Finlay gave his opinion of the electric light, observing, however, that he had not seen it in Paris, and, therefore, his opinion was based on what he had read in the reports of several gentlemen, who, he said, were fully competent to give an opinion. He referred particularly to the report of Mr. Sugg, who had been to Paris on behalf of the Gaslight and Coke Company, and whom he regarded as one of the best authorities on the question. He then stated that he had no fear of the matter, and certainly should not disturb his investment in gas companies. His impression was that the electric light might be used for railway stations, public lights, or large squares. It was not a matter to be treated lightly—it was well worth consideration; but it seemed to him that it was never going to be introduced into dwelling houses. That was his impression at the present time. If the gas companies were to lose the public lights, and those at railway stations, they would still have a very large rental. He thought there was a good deal in the remarks of Mr. Leng [at the London Gaslight and the Phœnix Companys' meetings, reported in *The Electrician* of last week]. That gentleman had given a great deal of attention to the question, and had stated that if the whole of the public lights were lost to the companies, it would only make a difference of one per cent. to them. [This latter and very important statement, however, was first made by a shareholder, at the last half-yearly meeting of the Chartered Company].—Mr. Pocock drew attention to a statement made as to the cost of lighting the Avenue de l'Opéra in Paris—namely, that with gas it cost 855*l*. a year, while the estimated cost of the electric light for the same number of hours was 10,600*l*.

At the half-yearly general meeting of the Commercial Gas Company, held on the 4th inst., Mr. Richard Bradshaw, the chairman, who presided, moved the adoption of the report, and in the course of his remarks said he had no doubt the shareholders were anxious on the subject of the electric light. The directors, too, thought that they ought to have every possible information about it, and that it was of no use shutting their eyes till they found out that a brilliant light was on them, and thus be taken by surprise. The course which the board had followed was that Mr. Robert Jones, the company's engineer; and Mr. J. Sprague, a well-known and able electrician, and a member of the Society of Telegraph Engineers, should visit Paris, fully investigate the subject, and report the result of the same to the directors. The report of Mr. Jones was as follows:—"To the Directors of the Commercial Gas Company.—Gentlemen: In pursuance of the instructions given me on the 13th ult., I have made an investigation of the modes of electric lighting as at present in operation in Paris and London, and have availed myself of the assistance of Mr. J. T. Sprague, the electrician, whom the Board authorised me to retain, whose report is appended. In furtherance of this view I have spent some eight days in Paris, and have gone through a large amount of matter and detail. With the time available since my return it is impossible to do more than formulate the facts obtained, and to briefly give the most salient of the conclusions I have come to—First, in the nature and quality of the lighting. Second, in its commercial aspect as touching any dangerous rivalry to gas lighting. I have adopted throughout the statements of the promoters of the schemes, as no means whatever are afforded by the parties for determining facts, those especially of the current cost of maintaining the lights being, as it seemed to me, studiously withheld. But in accepting these statements, it is obvious that the usual bias, even of candid inventors, must be allowed for, especially as no one is in a position to contest them. As to the efficiency and quality of the light, I think it may be conceded that on both the systems (Jablochkoff and Lontin) the single subdivided lamp is equal, when directed on the screen of a photometer, without the intervention of any glass shade, to, say, 600 sperm candles—such as are the standard in England—but at any considerable range, unless a reflector is used, and a translucent lens to concentrate and project a beam of light, I am of opinion that less than half this effect is obtained; in other words, the volume of light, scattered equally around the centre of illumination for any extent of area, is very much below the photometric power at short range. Beyond this the use of the opaline shades discounts the illuminating value by the commonly accepted ratio of 60 per cent. The difference in power between the diffused light from a shaded lamp and the projected beam of a reflected lamp, through clear lenses, is not likely to strike the casual observer; but when thrown into comparison, as I observed them at the great Hippodrome in Paris, the effect is most marked. That the effect in diffused light is much below the photometric value of the naked light is further evidenced by the fact that there are 34 lamps within the limited space of the Avenue de l'Opéra, which corresponds in London street-lighting to a space usually fitted with about 50 lamps of, say, about 10 candles each —*i.e.*, 34 lamps at 600 candles = 20,400 candles, against 50 lamps at 10 candles = 500 candles—but there was certainly nothing like such a comparative effect as this, although, of course, the place was splendidly lighted. I am rivetted in the belief that, powerful as the light admittedly is, its effective value is very much below that assigned to it. With regard to the distribution of the lamps in reference to the position of the motive power, I observed that in no case, in either of the systems, were the lamps placed beyond a distance of 200 yards from the engine; and, as it has been stated without contradiction that beyond this range there is a considerable loss of intensity in the current, I take this state of things to be a significant corrobortion of the statement, as it would be the easiest thing in the world for the promoters to insert a longer cable and settle the question if it were not so. If this be so, it forms, perhaps, the most formidable difficulty in the way of establishing the system for general purposes. In all systems the lamps have to be visited at intervals of a few hours to fix fresh carbons. In Jablochkoff's lamps the light is maintained at this time by a duplex arrangement; in the others the light has to be extinguished. With regard to the possible competition with gas in the case of a district where an established supply at a low price exists, as in that of this company, I have come to the deliberate conviction that, in its present form, its sphere is exceedingly limited; though to that limited extent I would not deny it a place, provided the economy of it is at all what the promoters state. Its field might be outdoor lighting, in long, straight streets of considerable width, and in large halls free from partitions and galleries, where the current expenses of attendance, &c., in a separate establishment would not bear too high a proportion to the amount of light required. But the main bulk of the gas consumers in the metropolis would be such as have a five-light gas-meter, and use perhaps seven lights in a ten-roomed house, fitted as a shop. These people have a vested interest in the present mode of lighting, as the gas-fittings will have cost them several pounds; moreover, many of their lights are only occasionally used, and others are small lights in passages, closets, &c., where, at the very smallest expense—perhaps not 2s. 6d. a year—the place is adequately lighted for their purpose. To offer to such a man, with no larger single chamber in his house than his shop of 20 feet by 15 feet area, a light, however magnificent, which involves a new installation and an illuminating effect ridiculously in excess of his wants, and in the smaller lights, necessarily more expensive, even if all costs but that of the carbons consumed be estimated, saddled with the necessity that, either by himself or in concert with his neighbours, he shall set aside part of his premises, and establish therein an engine and boiler house filled with suitable machinery, which, at the acknowledged minimum rate of one-horse power per light, would mean no inconsiderable matter both in room and expense; to tell him he must employ a qualified stoker for the hours of illumination, and, further, that he must maintain the wear and tear of all this machinery, and settle with the insurance office on the head of his putting up a steam furnace also, could provoke but one answer: 'The light I have answers my purpose, and I can cheaply add to it. I can afford neither the room, the time, nor the cost involved in the change.' I have selected this illustration to show the immediate objections of a solid practical kind which intervene between this otherwise attractive and imposing light and the ordinary gas consumer, because it is only by putting aside the glamour of the first impression made by the power and intensity of the new light, and looking at it from the bare dry view of how to make it available in ordinary cases, that its true position in competition is to be seen. I have to add, in conclusion, that, having given this question my most careful consideration, I am led to the belief that the new light is entirely unsuited for shops and private houses, not only on account of the complex and costly machinery necessary for its production, but because of its greater cost as compared with gas. That it will eventually occupy a place in the whole system of lighting I have

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no doubt whatever, but it will be of such a limited extent as not in any appreciable degree to affect or intefrere with the financial interest or prosperity of gas companies." (Signed), "Robert Jones, Engineer-in-Chief, Commercial Gas Company."—Mr. Bradshaw was about to read the report made to the directors by Mr. Sprague, but the meeting decided that it would be preferable to have it printed and circulated among the shareholders. He, however, stated briefly that it confirmed opinions expressed by Mr. Jones as to the value and use of the electric light. He himself had visited Paris, he then continued, and he must say that he was disappointed with the light after what he had heard of it, and it was certainly not the effective light he expected to find it. The directors had every confidence, in spite of the electric light, of meeting proprietors from half year to half year, with as favourable a report as they did that day.—The report was unanimously adopted, and dividends for the past half year, at the rate of 10*l*. 10*s*. per cent. per annum on the old stock, and of 7*l*. 10*s*. per cent. per annum on the new stock, were declared.

/ The report of Mr. Sprague, referred to above, is a far more lengthy document than that of Mr. Jones. After speaking of its uses—referred to below [and under this head he alludes to the light being a fluctuating one, and to its being rapidly lost in the distance] Mr. Sprague deals with the cost of the light, about which he says it is impossible to obtain any real definite information, and they could only take "at a suitable discount" the statements of the interested parties. Mr. Sprague then continues :—"The price of the Gramme machines used with the Jablochkoff candles at present is 400*l*. for the size working 16 candles ; the fittings of each lamp cost 8*l*., and the two conductors together 3*s*. 6*d*. per yard of distance. The expenses of fitting up are to be added, and the prices, being at Paris, would be a good deal higher here. Besides all these, an engine of at least 20 horse-power must be provided. The hourly cost of working is stated at 8*s*. 8*d*. per machine, or 6½*d*. per light, to which must be added an allowance for depreciation, repairs, and interest. Making the very best of it, the expense cannot be less than 8*d*. per hour per light; but any calculation based on this, without taking into consideration the circumstances of any particular case, would be so vague that I shall confine myself to the one distinct statement agreed to by all the interested parties—that each single light consumes one horse-power of an engine besides all the incidental expenses. In the Lontin system, I believe that the first cost is less, and also the working expenses, to some extent. But I know that the light exhibited at the Gaiety tries to the utmost the power of a 12-horse engine. The light produced is stated at 100 Carcel lamps for regulators, and 80 for candles. There is some doubt about the value of the Carcel lamp in our standard candles, but Mr. Sugg values it at 9·5, and I will use this value as being the highest. This gives us 950 candles for the one, and 760 for the other light, both naked. I greatly doubt this value. I found no difficulty in steadily examining the lights at a distance of 12 or 15 feet, and cannot believe that my eyes would endure the light of 760 candles gathered into a point no larger than a sixpence. The lights are actually used in opal glass globes, which are said to absorb one-third of the light. The best experiments, I believe, show that—Plain glass absorbs 10 per cent., ground glass absorbs 30 per cent., opal glass absorbs 60 per cent. This would give the actual light (taking their own value for the candle itself) as 300 standard candles. Ordinary gas, properly burnt, will give at least the light of 14 candles for 5 feet per hour—that is to say, 1,000 feet give for one hour a light of 2,800 candles, at a cost of say 3*s*. 4*d*. Assuming that the electric candle gives the 300 candles, and that its cost per hour is only 8*d*., the cost of the same 2,800 candles is 6*s*. 2½*d*.—that is to say, that, for equal quantities of light, the electric candle costs, on the figures of the interested parties, nearly twice as much as gas does ; and to attain this result, all the trouble and risk of machines and engines must be incurred, as compared with the simple turning on a tap. On the other hand, the electric light has well-known advantages ; and, further, these figures are but approximate values for results already attained, while it cannot be doubted that greater improvements will be made. In fact, I am cognizant of, and have seen in operation, a machine very much simpler and less costly than those now used, and which, as far as I can judge, will take considerably less power to work it. But the same remark applies to gas, for there is wide room for improvement in the burners and fittings to enable the gas to do its work. One of the effects of the excitement about the electric light will be to stimulate endeavours in this direction. Turning now to the influence likely to be exerted upon gas interests, it is very evident that the electric light has a place to fill, in which it has advantages over gas, and in which it must be expected to gradually replace it. But it is also evident that such uses are limited by the cost of working, by the large outlay involved, and by the specific nature of the light. We cannot limit the inventive faculty, but there is little probability that the electric light will be adapted to domestic uses. For street lighting, some very great advances must be made in the direction of economy beyond what is yet done before there is much chance of seeing electric lights used, except possibly in a few crowded crossings, such as Charing Cross or Oxford Circus. The case is not to be compared with Paris, where, as before stated, the relations of cost are also very different. Paris is a great fair or bazaar, and the people live in the streets, which are filled with beautiful buildings and manifold sources of attraction. Abundant light is as much a part of their stock-in-trade as it is in our public houses, and it pays them to disregard its cost. Neither our climate, cities, nor habits of life are the same, nor do they offer us inducements to adopt the same course as would suit Paris, where the gas lighting is so profuse that, in the Rue de la Paix, for instance, the lights are equivalent to one good burner every 4½ yards. The illumination there, if not so vivid, is, practically, quite as useful as the electric light in the adjoining Avenue, in which an exactly similar system of lights was, and still is, used after midnight. In railway stations, large halls, and in manufactories, the light will no doubt be used, but its introduction will be gradual, and its utmost effect will be to reduce the annual increase of consumption of gas ; it is not likely to touch the actual consumption by which dividends are earned. On the other hand, there is a nearly new field opening for gas in the form of gas engines. These are receiving great improvements, and from their safety and convenience, and from the fact that they require scarcely any attendance, are destined to replace steam engines to a great extent. In fact, should the electric light come into much use, it is most likely that gas will be called upon in very many cases to supply the motive power. There are also other undeveloped uses for gas which will compensate for any amount of reduced consumption at all likely to result from the electric lighting. Finally. It needs no prophetic power to foresee that ere long a dead set will be made in the market, both upon gas shares and upon the pockets of the British public, the natural prey of the 'promoter.' Many timid shareholders will sell, as always happens under similar circumstances, and it is highly probable that shares will suffer for a time a reduction in price. But I feel no hesitation in expressing the conviction, after full examination of the subject, that the gas companies of London have nothing whatever to fear, and that whatever may happen to gas shares, owing to market operations, gas dividends will not suffer the reduction of a shilling by any competition with the electric light."

At the half-yearly meeting of the South Metropolitan Gaslight and Coke Company, held on the 7th inst., Captain Heathorn, R.A., the deputy chairman, presiding, the report of the directors was adopted, and a dividend for the half year at the rate of 11¼ per cent. per annum was declared. A resolution was also proposed converting and consolidating into stock the company's shares. At the close of this business Mr. George Livesy, the secretary and engineer of the company, in reply to Mr. Storr—who asked for some information relative to the electric light, in which he expressed his utter disbelief—said he had hitherto refrained entirely from saying anything about it, because human nature was so perverse that anything one might say was apt to be twisted. He believed it was quite possible by talking so much about this electric light that they were doing more harm than good. There had been a further depreciation in gas shares with all that had been said, for the public were apt to think that there must be something in the electric light, or so much would not be said about it at the meetings of the gas companies. He did not think any of the shareholders were afraid of it. He himself would be glad to see the electric light cheapened and improved, and made available for lighting large open spaces in our streets. The City of London was very badly lighted indeed, and if the electric light could be brought to bear on such places as the front of the Mansion House, Queen Victoria-street, or the large wide streets, the public would never be satisfied with the same modicum of light now to be seen in side streets ; they would want more gas. It had been stated at a public meeting of the Chartered Company that if the electric light deprived the gas companies of the whole public lighting it would only affect them to the extent of 1 per cent. This, however, was a mistake ; it ought to have been stated that this deprivation would affect the gas companies to the extent of between 7 and 10 per cent. But then, if they were deprived to this extent, it would amount to only one year's increase ; and, so far at this company was concerned, they would in that case make no additional plant for twelve months. This was assuming that the electric light could be used for all the public streets. He maintained, however, that it was not a fit light for this purpose, for they did not want a concentrated light, but a diffused light. The electric light could not be diffused ; they would have very brilliant centres of light at long intervals, and as they increased the distance from a light they had to increase its intensity enormously—not in proportion to the distance they were from the light, but according to the square of the distance. Suppose, that was to say, he was ten feet from a given electric light—and he was enabled to read a newspaper by that light at that distance—if he removed the light to a distance of 100 feet, he wanted 100 times as much light to give him the same amount on his newspaper ; the light must be 100 times as strong, though it was only ten times the distance away. There was no doubt that we wanted more light, but we wanted it diffused and not concentrated. There was another objection to the electric light, which he thought was insuperable, inherent as it was to the light itself—its extraordinary intensity. So far as he was able to see, an electric light giving a light of 2,000 candles was no bigger than a finger's end. They could not diminish the intensity, and, therefore, for the purpose of ordinary lighting, he maintained that the electric light was totally unsuited, as it must be screened so as to destroy 95 per cent. of the light it gave. He had seen the light outside the Gaiety Theatre, and was thoroughly disappointed, and he could only say to any shareholder who was afraid "Go and see it ;" nothing like that was going to interfere with their property. It was commonly supposed that electricity could be produced for nothing, but this was a mistake, and if they were to have the electric light, so far as light for light was concerned, this could be got with gas at a much smaller expense. But if the electric light could be made as cheap as gas light it would be rendered totally impossible for ordinary lighting purposes. If it should "snuff out" gas, he would be completely ruined, for 95 per cent. of his eggs was in this basket. He should not sell a single share, and, if he had lots of money he would buy a great many.—Mr. Hobson said the electric light was better managed in Paris than here. The whole of the Avenue de l'Opéra was lighted with it. There were 46 lights, and they had a very nice way of subduing the globes, which were better covered than at the Gaiety. The great thing against the development of the light, however, would be the necessity to employ a steam engine. [Mr. Livesy : A gas engine would do.] On the whole, there was no doubt that the electric light was very much more expensive than gas. He considered that it might be introduced into large squares. As to comparing it with the poor light given in London streets, this was unfair, the fault being with those who contracted for the gas in London. With an extra quantity of gas double the present light could be obtained from each lamp. In his town (Sheffield) six feet per hour was paid for [Mr. Livesy : It is five feet here.] If the thing should be proved practicable the Sheffield Company was not at all sure that they would not ask Parliament for powers to supply the electric light. In many places, however, they knew, he said, that it was utterly impossible to burn the light. He had no doubt that gas would hold its own, particularly when it was as cheap as in the case of this company—3*s*. per 1,000 feet—and in his town, where it was only 2*s*. 7*d*. per 1,000. It would be a very ingenious invention, indeed, that would be able to give so much light at a less cost than 2*s*. 7*d*. per 1,000 cubic feet.—Mr. Butter observed that there was great difficulty now in finding employment for the rising generation, but, if the electric light came into use, it would be a good thing to bring up their sons as oculists, as he believed there would be abundance of employment for them.—Sir Charles Crossley also expressed his disbelief in the electric light.

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NOTES.

Electric Light.—We learn from St. Petersburg that preparations are in progress for illuminating the streets of the Russian capital by means of Jablochkoff's Electric Light.

Submarine Cables Trust Company.—The coupons of the Submarine Cables Trust due on the 15th inst. will be paid on and after that date by Messrs. Glyn, Mills, Currie, and Co., 67, Lombard-street, E.C.

Atlantic and Pacific Company.—The Atlantic and Pacific Telegraph Company, which recently concluded pooling arrangements with the Western Union Telegraph Company, has declared a quarterly dividend at the rate of 3 per cent. per annum.

Shoreditch.—Shoreditch being sweetness and light, the Vestry are going to illuminate the ratepayers with electricity, and say, as Macbeth did, "Out, brief gas!" St. Leonard's, Shoreditch, means to cry, "After me, whoever likes can be first."—*Metropolitan.*

Cost of Electric Lighting.—According to M. Jablochkoff, the proprietor of the Théâtre du Châtelet paid until recently 30fr. a night for gas, which has now been replaced by the electric light, at a cost of 14fr. The light is obtained by means of the *bougies* of the above-named inventor.

Eastern Extension Company.—The Eastern Extension Telegraph Company notifies the restoration of telegraphic communication with Australia. The Java Port Darwin cable is, however, still undergoing repairs, and until these are completed the traffic will be somewhat delayed. Telegrams for Australia and New Zealand will be accepted, as usual, *viâ* "Eastern."

Brazilian Submarine.—The directors of the Brazilian Submarine Telegraph Company (Limited) announce that the profits for the year ending the 30th of June are sufficient to enable them to recommend a final dividend of 2*s*. 6*d*. per share, making, with previous distributions, 5 per cent. per annum, and to carry 50,000*l*. to the reserve fund, which will then amount to 170,000*l*.

Globe Telegraph and Trust.—At a board meeting of the Globe Telegraph and Trust Company (Limited), held on Friday, October 11, it was resolved that the interim dividends for the quarter ending October 18, 1878, shall be 3*s*. per share on the Preference Shares and 2*s*. per share on the Ordinary Shares; and that the warrants shall be payable on and after the 18th inst. The transfer books will be closed from the 12th to the 18th inst., both days inclusive.

Intensity of the Electric Currents of Bell's Telephone.—In a circuit of two connected telephones, presenting together a resistance of 70 Siemens' units, or $68 \cdot 10^{10}$ Weber's units, the quantity of electricity circulating in consequence of the oscillation of the plate = 0·000000091 electromagnetic units. This quantity could only decompose $8\frac{1}{2}$ 10-millionths of a microgramme (0·001 milligrm.) of water. A sound of 880 simple vibrations, which would communicate to the plate vibrations of a micron of amplitude, would produce in the circuit currents whose mean intensity = 0·0000792.—*Archives Neerlandaises.*

America v. England.—One of the great characteristics of the Americans is the eagerness they show to adopt the hundreds of minor inventions calculated to save daily labour and add to the comfort of the house. In visiting the Paris Exhibition we were amazed to see the numberless ingenious devices for household purposes. It seems, again, that they employ electricity in a hundred different ways unknown here. The matron has a motor to run her sewing machine, the grocer to turn his coffee mill, the dentist to aid in his work, and so on. We are informed that an attempt is being made to introduce one of these simple and inexpensive motors into England, and trust the event may be successful.

Football by Electric Light.—The intense interest aroused by the application of the electric light to novel uses was strikingly apparent on Monday night in Sheffield, when nearly 30,000 people gathered at Bramall-lane Grounds to witness a football match played under that light. The match, which was played by two teams belonging to the Sheffield Football Association, commenced at half-past seven o'clock. The electric light was thrown from four lamps 30ft. from the ground, and the rays, which were of great brilliancy, lighted nearly the whole of the ground, the players being seen almost as clearly as at noonday. The brilliancy of the light, however, dazzled the players, and sometimes caused strange blunders. The illuminating power was equal to 8,000 standard candles.

Divisibility of the Electric Light.—M. P. Jablochkoff writes to the *Correspondance Scientifique*, in reference to the statement in *The Times* of the 8th inst., to the effect that the subdivision of the electric light was a problem of which the solution was reserved for Mr. Edison. M. Jablochkoff says:—"I long since realised the divisibility of the electric light, as is proved by the communications made by me on this subject to the *Académie des Sciences*, at their sitting of Dec. 3, 1877, and to the *Société Francaise de Physique* in its sitting of Feb. 1, 1878. This divisibility of the electric light was, moreover, demonstrated in public during the conference of Professor Janin in the great amphitheatre of the Sorbonne, Feb. 9, 1878; and, what is stranger still, this system has been at the Exposition since 1st May, 1878, and open to the examination of anyone visiting the Champ de Mars.

The Jablochkoff Light.—On Wednesday, the 15th October, the Jablochkoff light was introduced into England by Messrs. Wells and Co., of the Commercial Ironworks, Shoreditch. The Jablochkoff candle is well known as consisting of two parallel strips of graphite, separated by kaolin. The earth melts as the carbons burn, and thus the apparatus is fitly called a candle. The machines used were those of Gramme, requiring a driving power equal to about one-horse power per lamp. The lofty show room of Messrs. Wells and Co. is admirably adapted for effectively showing the value of electric lighting. Four lamps are placed inside the show room, and two outside, at the entrance. We trust that Messrs. Wells will not hesitate to give some account as to the real cost of the light, for hitherto one of the most difficult things to obtain has been an authentic statement as to the actual cost of the Jablochkoff light.

Telegraphs.—Professor Neumann-Spallart, of Vienna, gives the following statistics relating to telegraphy. At the commencement of the year 1877 Europe possessed nearly 218,000 miles of telegraph, of this 40,300 miles belonged to Russia, 33,500 miles to France, 29,800 miles to Germany, 25,000 miles to the United Kingdom. The length of wire was nearly 700,000 miles. Upon these wires in 1876 were transmitted some 82,000,000 despatches. The junction of Europe with other parts of the world was effected by three land lines to Asia, and by 560 submarine cables having a length of 65,000 nautical miles. America at the same period had 113,460 miles of line, and transmitted 23 millions of

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despatches. Asia and Australia had each about 25,000 miles of line, upon which 2,500,000 of messages were sent. Africa had only about 8,000 miles, principally belonging to Egypt, Algiers, and Tunis, upon which 1,200,000 of messages were sent.

TROUVÉ'S PORTABLE CONSTANT BATTERY WITH DANIELL'S ELEMENTS.—Amongst the various electrical inventions shown at the Paris Exhibition the very portable "constant" battery of M. Trouvé deserves mention. The zinc and copper elements are in the form of discs, separated from each other by a number of sheets of blotting paper of the same form. The copper element is placed beneath the zinc, and the lower half of the discs of blotting paper is saturated with sulphate of copper, the upper half being similarly saturated with sulphate of zinc. To excite the battery the elements are immersed for a few seconds in water. If they be then kept in their ebonite box, the battery will remain in action for over six months, zinc and sulphate of copper being in this case consumed whether the circuit is closed or not. By dipping the lower portion of the elements in a solution of sulphate of copper, the battery may be recharged. If the battery should be required for use only at distant intervals, the elements may be exposed to the air and thus dried, when they may be put aside and kept without any consumption of material.

THE SINGING CONDENSER.—Under this title, *L'Electricité* describes one of Mr. C. F. Varley's telephonic inventions intended for the transmission of musical sounds. This apparatus is now being exhibited in Paris, where it is exciting a large amount of public curiosity. It appears to be similar in most points to that exhibited some time back in London; but we cannot remember that any carbon contact was used in the latter. It is composed of three parts, viz., a telephonic transmitter, which is in principle similar to Edison's —the pressure between two carbon pieces being varied by the vibrations of a diaphragm; secondly, an induction coil, through the primary wire of which, connected with the transmitter, a battery of six Leclanchés is circuited; and, thirdly, a condenser of twenty-eight sheets of tin-foil, separated by paper (paraffined); this condenser being connected with the secondary wire of the coil. A tolerably heavy weight placed upon the sheets forming the condenser has no effect upon the sounds produced, which are loud enough to be heard throughout an apartment. The tones are not always very pure, but under favourable conditions approximate to those of the violoncello or hautbois.

NEW TELEPHONIC TRANSMITTER.—(P. Dumont.)—This system, which has given the author results superior to those of any other apparatus of a similar kind which he has been able to try, is a combination of the pack-thread telephone and of the electric charcoal microphone. A parchment membrane of twelve centimetres in diameter is stretched over a vertical frame. In its centre is fixed a thread secured by a knot on one side, and which, taking, on the other side, at first a horizontal direction, passes round a small pulley and supports at its other extremity a small cone of brass suspended by a hook fixed to the centre of its base. This piece, which is relatively speaking tolerably heavy, plunges its point to the depth of about one millimetre into a metallic cube full of powdered gas-coke, and fixed upon the horizontal plate, which, forming the foot of the apparatus, supports the stem of the frame fitted with the diaphragm. One of the poles of the battery (a Leclanché of four elements) is connected with the metallic cone, and the other with the cube containing the coke-dust. The slightest vibrations imparted to the membrane by sound-waves suffice to modify the pressure of the cone in the coke-dust, thus determining variations in the intensity of the current.—*Comptes Rendus.*

INDICATIONS OF PROGRESS.—Whilst Paris has been revelling in excess of light, and, according to many, paying pretty heavily for it, we have been waiting the results of the experiments. However, amidst the confusion of cries, there seems to be a general consensus of opinion that electricity is the best method of lighting under certain circumstances. This being the case, efforts are being made to supply any demand that may arise. No less than three electric light companies have been registered within the last few days, with a total capital of over 200,000*l.* The British Electric Light Company, promoted by Mr. E. J. Reed, takes up Rapieff's patent, and is patronised by *The Times.* The Electric Lighting Company, promoted by Mr. Hollingshead, is to work the Lontin system, and is patronised by the frequenters of the Gaiety, and all who walk through the Strand during certain portions of the evening. These two have a nominal capital of 100,000*l.* each. The Sun Electric Light Company is the third and last, with a capital of 5,000*l.* only. Mr. Strickland is the promoter, and the company is formed for the development of the Harrison system, about which little has been publicly said, but which private report mentions in the highest terms. The candles are said to surpass the Jablockhoff, and the division of the light seems to anticipate Mr. Edison. The public will soon be able to judge the value of these reports for themselves, as arrangements are being made to use the light on a very large scale.

NEW ELECTRICAL DIAPASON.—Mr. G. M. Hopkins, in the *Scientific American* of October 12, describes a new instrument he has constructed. The article is amply illustrated. His reasons for investigation in this direction will be understood from the following quotation:—"The graphic method of studying vibratory motions is deeply interesting, especially in these days of telephones and phonographs, when the properties of sound are being more thoroughly investigated than ever before. Several methods have been devised to render sonorous vibrations apparent. In the novel and beautiful method of M. Lissajous, two tuning forks or diapasons, each carrying a small mirror, are arranged so that by their combined movements a beam of light is reflected, forming upon a screen beautiful symmetrical figures, by which the vibratory motions of two sounding bodies may be compared without the aid of the ear. Sir Charles Wheatstone, many years ago, contrived a small machine for compounding rectangular vibrations; and Professor E. A. Dolbear more recently devised an apparatus to be attached to a whirling table, for the purpose of vibrating two mirrors in different planes for projecting Lissajous' curves. These curves have also been drawn by means of pendulums. In each of these forms of apparatus some desirable element is wanting. The forks lack continuity of action. The vibrating mirrors of Professor Dolbear may be operated continuously, but no sound accompanies their movements. The pendulum, while it produces beautiful figures, has neither the sound nor continuity of operation. With a view to the construction of an instrument that would operate continuously and produce both sounds and figures, I first arranged two reeds or tongues to be vibrated by an electric current. These tongues were made adjustable as to length, so that their vibrations might be varied to produce fractions of a tone to illustrate the phenomena of consonance and dissonance. To each tongue I attached a mirror, and at first used the apparatus after the manner of M. Lissajous' tuning forks. I subsequently combined the two tongues in one instrument, and connected them both with a single mirror, so that it was actuated by both tongues."

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THE PROGRESS OF SUBMARINE TELEGRAPHY.

It is well, now and then, to look back and observe the state of any branch of telegraphy at an early date, and then to trace the principal changes and improvements that have taken place up to the present, in order, as it were, to take stock and to see if the advance has been at a healthy rate, and thus warrants a belief in a further rapid improvement. In the case of submarine telegraphy, the cables employed form the first item to be considered, the conductor the first part of these. The first conductors were of solid copper, which broke at brittle places when badly annealed, and caused wants of continuity in the most dangerous way, for the broken ends would touch and defy all attempts at detection until the cable was actually under the strain necessary to the operation of paying out. This was remedied by using a strand of three, four, five, or seven wires, the chances of all breaking at the same place preventing the chance of want of continuity. The joints, consisting of a scarf and lapping of fine wire soldered throughout the whole length of the lapping, used sometimes to break right through solder and lapping wire. This was obviated by a second lapping of fine wire, only soldered at the two ends, so that when the joint broke the fine wire did not, and kept up the continuity. The copper employed was found to vary enormously in conducting power, and it was found that some specimens were not up to that of pure copper by 50 per cent. By experiment on various kinds this, as is well known, has been remedied, and most conductors now have a conductivity within five per cent. of pure copper.

The bounding surface of a strand conductor as compared to its sectional area being greater than in a solid wire of the same section, and thus giving a slightly higher electrostatic capacity to the former, attempts have been made to make a circular conductor built up, as it were, of several parts, so as to combine the advantages of the strand with that of the solid wire. Thus, on the Persian Gulf cable, the strand was made of five parts, four being quadrants in section, and the fifth that of a ring embracing the four. A break of continuity nevertheless occurred in this, and it has not been used on any other cable. In the "Direct United States" the ratio of the electrostatic capacity of the conductor to its section has been reduced by using a large central wire surrounded by a great number of small ones. Here the improvements in the conductor rest. In the insulating medium the earlier cables consisted of gutta percha at first laid on in one single coating, soon increased to two, so that any slight holes in one coating might be covered by the next. The interstices round the strand conductor leaving an air space, this was found objectionable, and was filled with a compound of resin, Stockholm tar, and gutta percha. This was also applied between the coats of gutta percha and was to fill minute holes and make the coatings adhere. The mastication and cleansing of the gutta percha were also increased, and thus the insulation has been vastly improved. The joints in the insulator at first consisted of merely thick sheet gutta percha applied warm, and were soon found to require more precaution. Thin sheeting was then used, and thick over it, and greater care taken to knead the junction between the covering thus applied and the regular coating at each end of the joint. In this way the resistance of gutta percha has been increased six fold at least.

Many efforts to supersede gutta percha by india rubber as an insulator have been made, and the nearest to success has been that which resulted in the manufacture known as Hooper's core. Pure india rubber was found to soften into a kind of fluid like tar, the process beginning always next to the copper wire. If the rubber was vulcanised, this action was arrested, but the sulphur in the rubber attacked the copper, and made sulphuret of copper. Hooper employed a layer of rubber containing oxide of zinc and other substances as a "separator" between the pure rubber round the conductor, and an outer coating of rubber containing sulphur. When this was cured by steam the sulphur vulcanised the outer jacket, and a small portion passing through the "separator," vulcanised the pure india rubber just sufficiently to prevent its turning tacky, the copper being tinned so as to prevent its direct contact with the rubber, and thus still further protect the pure rubber from turning "tacky."

Hooper's core gave very high results, when new giving an insulation resistance of more than twenty times that of gutta percha, with a higher inductive resistance, but it appears on the whole to be uncertain. The second Persian Gulf cable laid in 1869, however, continues in working order, and, although it has declined, is still higher in insulation than the gutta percha cable there. The Western Brazilian lines have, it is well-known, given much trouble. It is to be hoped that the efforts to overcome the difficulties of india rubber will not cease, as the vulcanised rubber has the great advantage of standing dry heat better than gutta percha.

Rubber has been used as an insulator by Henley and the India Rubber Company with more or less success, but on the whole it does not appear as if gutta percha has much to fear at present from its rival, although, undoubtedly, India rubber, by the high insulation it gave when first employed, has at least served to stimulate the improvement of gutta percha to the high perfection it has now attained, although the insulation obtained is still far below that of Hooper's core when new. On the whole, a very great improvement in the soundness and certainty of the insulation has been obtained.

We have next to consider the mechanical protection of the insulated wire. In the earliest cables for shallow water, this consisted of galvanised iron wires laid round over a bedding or serving of hemp or jute, which surrounded the insulated wire or wires. In this, for shallow water, the improvements have been the further protection of iron wires from rust by coatings of hemp, pitch, and silica, since improved by employing a band of rough canvas, instead of hemp yarns, with the pitch. In rough localities two separate sheathings of wires are sometimes used, and, where anchorage is to be feared, the outer sheathing is made of strands of three wires each. The cables, through anchorages, and near the shore, are much heavier than they were originally, weighing sometimes as much as 20 tons to the knot. On the whole, the improvements here have not been very great under this head, for the hemp covering only lasts in very still water; and is rarely, therefore, of much use in very shallow water.

As regards deep-sea cables, the sheathing of the first Atlantic and Mediterranean cables consisted of small iron wires not even galvanised. This has been improved by using wires of homogeneous iron, a kind of steel, galvanised and further protected by hemp and pitch. These are, therefore, very much stronger. In some of them the hemp is laid round each wire, and forms part of the longitudinal strength of the cable, thus making the cable lighter in water for a given strength, part of the strength being thus given by a material that is lighter in water than the steel. Thus, cables have been made that would bear a far greater weight in proportion to their weight per mile than formerly; in other words, they would bear a greater length of themselves than the earlier cables. Thus the present Atlantic cables would bear about 14 miles of their own length when new, whilst the earlier cables would barely support five miles. These cables, whose strength depends on the hemp, however, rapidly decrease in strength as the hemp decays. The other deep sea type, where the steel wires are not each separately served with hemp, are only stronger than the earliest cables by the excess of the tensile strength of homogeneous iron over common iron wire, or about 50 per cent. The serving of hemp and pitch, however, must add to their life in the still water of a deep sea. The further improvement of using the rough canvas instead of strands of hemp, obtains here also, as it is stronger and less liable to peel off.

One of the greatest improvements in submarine cables was of a negative kind, and consisted in abandoning the use of tar in the soft serving round the insulated wire. This tar filled up and disguised minute and even large faults. As the tar was gradually dissolved by the sea water, the faults developed and became enlarged by the working currents. The serving, being now applied wet, keeps the surface of the gutta percha wet, even when the cable is not itself immersed in water, and thus facilitates the detection of faults.

The improvement in the means of testing is perhaps the greatest advance we have made in submarine telegraphy. The introduction of resistance coils, the Wheatstone bridge, and the reduction of the insulating resistance to a definite measurement in units of resistance per unit of length of wire, and the general adoption of common units of resistance and electrostatic capacity, and the tables for correction for temperature, have been of the utmost use in affording correct and comparable measures of the electric state of any cable at any time. The more sensitive galvanometers, such as the astatic mirror, have also allowed of more delicate tests, and the mathematical knowledge brought to bear have permitted of the localisation of faults that in the earlier days could never have been discovered until they had developed into dangerous sores.

The introduction of signalling instruments of great sensitiveness, such as the mirror, has allowed the cables to be worked with a mere fraction of the battery power formerly employed, thus avoiding the danger of enlarging minute faults by the current used in signalling. The employment of condensers in working submarine cables, to combat the difficulty of earth currents, and, finally, the successful employment of what may be termed resistance condensers giving electrostatic capacity for each fraction of resistance for the use of duplex, is the latest improvement.

The more careful survey of ground, and the heavier and longer shore ends employed add considerably to the security of cables, whilst the more careful mapping of the lines permits of the cable

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being grappled for repair of faults with greater certainty and rapidity.

As regards the process of laying, the principal improvements have been in the employment of circular coils, with central support, with conical or telescopic centre, with large rings to prevent the cable from lashing about in its path round the centre, more perfectly arranged guiding paths from the centre of the coil to the paying-out gear, the Appold break to keep a more constant strain on the paying-out gear—though this is not always employed—and the employment of dynamometers to observe the strain on the cable. The employment of water-tight tanks, so that the cable can be kept under water, both preserving the gutta percha and facilitating the electrical testing, was also a great step. The fitting of every paying-out ship with a picking-up gear, so that she is enabled to haul back the cable if a fault is detected in the cable passing from the ship, and the proper supply of buoys to the paying-out ship, so that she can drop them at a doubtful fault, and go on paying out if necessary, are all steps that have been gradually brought about by time and experience. In the repair of cables the improvements have consisted principally in providing stronger and more powerful machinery for picking up rather than in any special steps. Of late, grapnels that will cut the cable and hold one end, and another, whose prongs yield to a certain strain when they catch in a rock, are the latest improvements. We have thus reviewed the principal improvements in submarine cables; the difficulties yet to be overcome to attain greater security are still numerous, but science and experience are rapidly solving them.

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Die Lehre von der Elektricität unö dem Magnetismus mit besonderer Berücksichtigung ihrer Beziehungen zur Telegraphie. Bearbeitet von Dr. O. Frölich. Berlin: Springer.

Geschichte der elektrischen Telegraphie. Bearbeitet von Dr. Karl Eduard Zetzsche, Professor der Telegraphie am Polytechnikum zu Dresden. Berlin: Springer.

Mr. Spottiswoode, in his presidential address to the British Association, pointed out the difficulties attending the speech from the chair. The difficulties experienced by the reviewer of a technical work, though less in degree, are like in kind. President and reviewer must alike be specialists, and the specialist must approach his work with certain preconceived ideas. In branches or subjects wherein his critical faculty is not exercised, the reviewer, perhaps, seeks for information which he does or does not find in the work before him, and when found the method of its presentation must determine in his mind the value of the work. Where the subject is in sufficiently narrow limits to come under the criticism of a single mind, and the verdict of the reviewer depends entirely upon his judgment, the labour is of love, and is easy. The contents of the first of the above volumes include branches of the science of electricity, proficiency in any one of which would need the study of a life-time. It is the second of a series compiled and edited by Dr. Zetzsche, and intended to include in the whole series a complete popular review of telegraphic and electrical science and invention. The first volume was devoted to descriptions of telegraphic instruments, and was under the care of Dr. Zetzsche himself. Its impartiality and freedom from error left little to be desired, as might be expected from one holding a professorial chair in telegraphy, that is, from one professing telegraphy as a science. But the care evidenced in the former volume no longer appears in the second; and this is the more to be deplored considering the amount of fresh and valuable information apparently at the Editor's disposal. One turns over but a few pages of the book in the first part, dealing with the "electrical state," and falls upon a table in which the substances it includes are divided under the heads of Conductors, Semi-conductors, and Non-conductors. Amongst the "conductors" are classed "linen" and "cotton;" amongst the semi-conductors, paper and straw; and, amongst the non-conductors, feathers, hair, wool, and silk. Marble appears as a semi-conductor; dry metallic oxides and chalk, as non-conductors. Such confusing cross-divisions it would be difficult to equal. The whole of this portion of the work is characterised by great looseness of definition and terminology. In the table of specific inductive capacities, that of "wax" is given, and the reader is left to infer from the position in the scale that "paraffin" is meant; and "gummi" is to be translated as india-rubber. The illustrations accompanying this portion of the work are, however, excellent. It is about this part of the book that the prevailing mention of one firm's inventions and manufactures, which characterises the entire work, becomes notable. When this has been said, and it is far too noticeable to be omitted, all further remarks must be in praise; but the continual reference to the chief telegraph firm of the "Vaterland" savours strongly of bias.

Dispersed through the work are many valuable notes. Amongst those affording practical hints may be quoted one referring to the electric light, and the effect upon the light of treating the carbons with various substances, from the experiments of Casselman:—

Nature of the Points.	Distance of the Points in Millimetres.	Intensity— Of the Current.	Intensity— Of the Light.
Pure Carbon	Very small. 4·5	90·5 65·3	92·3 139·4
Carbon, treated with Sulphate of Strontia	0·75 6·75	101·5 83·0	336·6 274·0
Carbon, with Caustic Potash	2·5 8·0	95·9 78·0	150·0 75·1
Carbon, with Zinc Chloride	1·0 5·0	76·6 64·1	623·8 159·0
Carbon, with Borax and Sulphuric Acid	1·5 5·0	67·3 60·6	1,171·3 165·4
Carbon, with Borax	7·5	46·0	205·4
Carbon, with Sodium Sulphide	6·5 7·5	36·7 36·7 44·3	236·6 177·7 400·0

From this it will be seen that a law appears to hold with every substance, that the light intensity increases more rapidly than the current intensity. The author states that he believes the suburatation of carbons to have only little practical application; but, from M. Carré's statements in communications to the French Academy of Sciences, it would appear that the carbons supplied by him are treated with caustic alkalies.

In this division is included the description of the electric lamp, although objection may be well taken to the fact that only one lamp, that of Siemens and Halske, is described. The Serrin lamp is far too generally used, not only in this country, but also on the continent, to be omitted in a popular text book.

An error, not confined, unfortunately, to Continental text-books, is to be found in the proposition of Faraday's law of electrolytic decomposition. It is stated that the quantities of the substances decomposed in an electrolytic cell are in direct proportion to their "*chemical*" equivalents. Though true in one sense, this statement is wholly erroneous as a scientific definition. For the term "*chemical*" should be substituted that of "*electro-chemical*," as qualifying the word equivalent, the electro-chemical equivalent being the chemical equivalent divided by the atomic valency, a difference of considerable importance in practice. For instance, the chemical equivalents of zinc and platinum bear the relation of 65·2 to 197·0, whereas the metals are deposited in the ratio of 32·6 to 49·25, and so on. The want of perspicuity in this matter is, however, compensated for by the clear way in which Ampère's laws with relation to electro-magnetism and magnetism are laid down and illustrated. The characteristic of the book mentioned previously is excepted in the description of the Gramme machine, the theoretical principles of which are fully entered into, the invention of the machine being, however, ascribed to Pacinotti. In several instances we have statements as to "the Pacinotti machine by Gramme of Paris." Now, the original Pacinotti and the Gramme machines, however nearly related in principle, are not identical; and, even supposing M. Gramme not to have reinvented the machine, the present Gramme machine differs so widely from the Pacinotti as to constitute it, in comparison with other electrical machines, a purely distinct apparatus. Statements of this kind, open to controversy, are much to be deprecated in any text-book. In treating of dynamo-electric machines, the author informs us that the principle was discovered by Werner Siemens in December, 1866, and by Wheatstone in February, 1867. These dates, it would be more correct to say, are the dates of the papers presented by these celebrated inventors to the scientific academies of their respective countries. Such references are, however, hardly to be considered necessary in a popular text-book.

A seventh section of this volume deals with the electric phenomena in cables. Here the general arrangement and the matter dealt with are both admirable. It is unfortunate that we have no similarly complete compilation of tables of the curves of tension in our English text-books, embodying the later investigations

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of Mr. Hockin and others. The long underground lines recently laid in Germany, and upon which the author has been engaged, give him great facilities for experimental verification, and his synopsis conveys very clearly the condition of the receiving end of a short cable during the discharge from a signal-wave.

The volume concludes with a section upon measurements and measuring instruments which is sadly disappointing to the English electrician, leaving out of court as it does the beautiful systems of Thomson, Maxwell, Jenkin, and Hockin, whilst the determination of cable faults is mentioned merely. The absolute system is also described; but here again is evidence of carelessness in correcting *lapsæ scribendi*. Whilst we have the ohm correctly given as 10^7, and the volt as 10^5 absolute units, the weber is given as 10^{-3} instead of 10^{-2} absolute units, which renders the confusion with Weber's current-unit worse confounding.

Of interest to the English reader are the following equivalent values:—1. Weber's current-unit (not one weber of current or a B. A. unit) = $\frac{1 \text{ Daniell}}{11{\cdot}7 \text{ Siemen's units}}$. The current from $\frac{1 \text{ Daniell}}{1 \text{ S. U.}}$ decomposes 1·38 gramme of copper per hour, and upon 1 S. U. resistance performs 11·6 grammetres of work per second, or heats 0·0271 grm. of water, or 0·285 grm. of copper 1° C. These numbers, though those of the B. A. system are, of course, more methodical, are convenient to remember.

The telegraphic constructor, when designing an instrument, needs to make constant reference to what has been done before, not only to know whether what he intends to do has been done better, but as well to seek help in overcoming difficulties. To have a *reliable* text-book at hand, giving details of machines and instruments to the latest date, is of invaluable assistance. Such an aid is the text-book of which Dr. Letzsche is the author, and it is to be hoped that the time is not far distant when some efficient translator will present a copy of this single volume to the English public, to continue and extend, but not replace, the "History of the Telegraph," by Mr. R. Sabine. To the general reader the book will furnish descriptions of a series of brilliant inventions that have become obsolete only through the steady growth of knowledge. That these brilliant inventions have not been flashes of genius alone, but the ultimate result of a long-continued series of labours, is amply evident to the reader of these pages. We cannot do more than refer readers conversant with the German language to the work, the illustrations of which will speak to all alike.

ON THE STUDY OF ELECTRICITY AS A PROFESSIONAL PURSUIT.

BY THOMAS T. P. BRUCE WARREN.

(CONTINUED FROM PAGE 233.)

Solder is a mixture of tin and lead, and, consequently, may contain all the impurities found in these metals. In consequence of the much lower cost of lead than tin, it is possible that the cheaper metal may be used in excess.

However, there is a great difference in commercial samples of tin, and it may be interesting to inquire to what extent the brittleness of tinned copper wire may be due to the impurities of the tin contained in the alloys used for tinning.

The quantity of arsenic contained in ordinary tin is said to amount, generally, to not more than $\frac{1}{600}$ part. The tin known as Banca or Malacca is said not to contain appreciable quantities of this metal.

Antimony is a metal which may be used in small quantities to adulterate tin. The influence which arsenic and antimony have in rendering metals brittle is a fact which appears to me to have been entirely overlooked by electricians. Cases have occurred where soldered joints in cables, &c., have, after a time, become so brittle as to break when handled.

When solder is required for telegraph work, it is far safer to mix the metals together than to purchase the article ready made.

Sheet lead can now be had representing a degree of purity = 99·96 per cent. pure lead, and even 99·996 per cent., a high degree of purity being necessary for the construction of sulphuric acid chambers.

The amount of these two metals may be ascertained by treating a weighed portion of the alloy with strong nitric acid, diluting with an equal volume of water, evaporating to dryness and washing out the nitrate of lead, and weighing the per-oxide, one grain = ·787 metallic tin. The difference will correspond to the weight of lead present.

If copper be present, the filtrate from the oxide of tin should be evaporated to dryness with a little strong sulphuric acid, and the sulphate of lead thus formed separated on a filter. The copper may be estimated by means of the solution of stannous chloride; or, if much iron is present, it may be separated by previously reducing the copper, redissolving and converting into sulphide.

Soldering solution is made by dissolving fragments of metallic zinc in ordinary muriatic acid. Here, again, is a most fruitful source of mischief; muriatic acid contains large quantities of arsenic. Pure muriatic acid can now be obtained at a cheap rate, and zinc free from arsenic is by no means such an expensive article as to be precluded from such purposes.

Galvanised iron wires are known not to be so strong as the ungalvanised wires; and I am not aware that any one has examined the effect which might arise from the use of muriatic acid containing large quantities of arsenic. The impurities contained in commercial spelter cannot be considered altogether harmless.

We know to what a state of perfection as regards purity iron is brought, and we are well aware of the influence which some of its natural impurities exert on the mechanical qualities of the metal, and yet we allow our best selected wires to come in contact with some of the most pernicious substances to be found. How far the absence of these impurities in the galvanised surface will add to the durability of the wire in submarine cables we cannot tell; the seriousness of such probabilities, so far as concerns the lasting of the metallic sheathing of deep-sea cables, must, sooner or later, attract the attention of manufacturers, if submarine telegraphy is to maintain the position of a commercial financial success.

If a galvanised wire be carefully amalgamated it will withstand the action of sea water much better than the same wire not amalgamated; but, as cable manufacturers appear to have a great horror in using anything poisonous on account of men having to work so closely at it, it is not likely that any suggestion in this direction will receive a trial.

Tinned iron wire is also very durable, and there appears to me no reason why, as it is less easily oxidised than zinc, it should not receive a trial for the outer sheeting of cables.

Oxidised iron, again, is wonderfully durable, resisting even the action of strong mineral acids; but, whether the sheathing of a cable with wire so protected could be ensured, is very problematical. Some applications of this oxidised iron have been recently patented by Professor Barff.

The fact that the attempts to repair the 1866 Atlantic cable have been so far unsuccessful, from the corrosion of the sheathing, which prevents its being raised to the surface, will, I feel certain, necessitate a careful investigation, if the confidence of the public counts for anything in the financing of cables.

According to M. Michelet, zinc free from arsenic may be thus obtained:—"Melt some commercial zinc, and, when very hot, pour it out into a deep pail of water. Gather the zinc thus granulated, and, if not in sufficiently small pieces, break the larger bits in a mortar, and place them in alternate layers, with one quarter of their weight of saltpetre, into a Hessian crucible, taking care to begin with a layer of saltpetre and terminate with a layer of zinc. Heat now the crucible, and, when the deflagration and fusion have taken place, remove the scoriæ, and run the zinc in an ingot mould; it will be found to be perfectly pure."

My experience of this process is that it will yield, if Belgian spelter be used, zinc so free from arsenic that it gives no trace of this metal when tested by Marsh's process. Lead, if it exists in large quantities, is imperfectly removed. The process does not yield zinc free from iron, although it seems to act more completely according as the iron is present in rather large quantities. Very small quantities of iron are only very slightly reduced.

Petroleum or Liquid Paraffin.—It is not necessary to say much on the chemistry of this substance, but as it is an indespensable article with the electrician for the lamps in the testing room, a few words may be necessary. Having witnessed three very awkward mishaps with this liquid on board ship, I think that no one ought to handle this substance without due care.

I would advise every engineer and electrician to make himself acquainted with the use of the little apparatus sold by Messrs. How and Co., 5, St. Bride's-street, Ludgate-circus, for testing the flashing point of paraffin oils, especially if required for sea use, or in warm climates.

I have no hesitation in saying that many losses at sea, where ships have never been heard of and missed in a most mysterious way, may be due to the accidental upsetting of a paraffin lamp. It must be fresh in the minds of my readers that the burning of a training ship on the Thames was attributed to this cause.

[TO BE CONTINUED.]

Mr. William Hooper, whose name is inseparably connected with submarine telegraphy, died on the 25th ult., at the age of 60.

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Es wird uns ein Vergnügen sein mit den löblichen Redactionen der deutschen und anderen continentalen Journäle und Zeitschriften, denen die ersten Nos. des ELECTRICIAN *zu Händen kommen möchten auszutauschen.*

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THE SCARE AMONG THE GAS COMPANIES.

During the past two or three weeks the gas companies have been holding their half-yearly meetings, and one and all have had something to say concerning the electric light. In almost every case there has been a qualified admission that the progress of electric lighting was not to be despised, and that, although the new light was calculated to be useful for certain purposes and in certain places, the shareholders had no reason to be alarmed. However, amidst the general uncertainty and uneasiness, many of the shareholders thought it best to be on the safe side, and the result of crass stupidity has been a sudden and general depreciation of gas companies' stock. We are probably in a better position to judge of what is likely to be done with the electric light than are the hundreds of busybodies and harpies whose object it is to prey upon their weaker minded neighbours. We thoroughly believe in the advent of the electric light; but we know also as thoroughly that the introduction of the light is a matter of time. It is not to be introduced in a week, or a month, or a year; its extension must and will be gradual, and, for a long time, although the property of the gas companies may not be so valuable, it will remain a fairly lucrative investment. The first work of the electric light will be to stop extension; but even this will take time; then will come gradual replacement, for, as a writer to *The Times* aptly suggested, what required years of solid workmanship to build is not to be destroyed in a day. We make these remarks in the interest of those hundreds of *bonâ fide* investors whose little all is locked up in gas shares, and to whom a difference of 20 or 30 per cent. represents years of saving. Still, at the same time, we must admit that the gas companies have no one to blame but themselves for the panic that has arisen. For years they have been paying large dividends, with little or no consideration for the public, and, whenever monopolists do this, it is merely an incentive to genius and science to circumvent monopoly and obtain a share of the spoil.

It is unfortunate that in the general excitement the voice of wisdom is unheard. The ordinary investor prefers the conclusions of the unscientific Press to those of that section of the Press which has made these things a special study. On the other hand, the dicta of the chairmen, managers, and other interested parties connected with the companies are utterly untrustworthy. It is said that the *sauve qui peut* was the result of a telegram from Edison, and a report of a conversation with him which originally appeared in the *New York Sun*, and which we produced in our columns last week. In this report there is absolutely nothing new. The subdivision of the electric light was not a question to be solved—it has long been solved. We are quite familiar with not one, but several methods of subdividing *ad libitum*, and we have for some time known of an English patent that professes, and we believe with justification, to carry out the subdivision in practice, nay further, to provide an electric light that can be used to illuminate the drawing room or the manufactory, that will burn for an indefinitely long period without any attention whatever, and that is at once simple and economical. Yet it must take many years before ever a perfect electric light will supersede gas. With regard to Edison, no doubt he has made some discovery. Such a genius could hardly turn his attention to so open a field without hitting upon something new; yet we shall be surprised if it is what the *Sun* reporter makes it out to be. Had he restricted his attention to "light" only, we could have said nothing; but, when one comes to talk about "heat," we have at once something definite and measurable. We know exactly the theoretic amount of heat obtainable by the most economical combustion of coal, and if we interpose an engine or other machine we lose a certain amount of this heat. We have yet to learn that heat can be economically transferred by wires, as would seem to be the case with this wonderful new invention, by which, according to the reporter, "the same wire that brings the light will also bring heat and power." That this might be done whilst utilising the natural force of Niagara, &c., may be imagined, but not when the machine is "run by steam power." It is possible that the reporter gave a certain amount of play to his imagination, and hence the confusion. Elsewhere we reprint an article from the *New York Sun* which gives important information about "light," but says little about heat. We shall, like many others, fook forward with some amount of interest to hear exactly what Mr. Edison has done, but we should be agreeably surprised to find he has made any very wonderful stride. We think the light of the immediate future will be that obtained by means of the apparatus referred to above. The progress of the electric light can easily be foretold. In the first place, we shall see it applied to large factories and railway termini; then to large halls and other places of public amusement, to the circuses and large spaces in the metropolis and other large towns; to the houses of the wealthy, large shops, and, finally, to the streets and smaller houses. It is altogether a mistake to suppose that the opening for the use of the electric light is immediately for street purposes. We would that it were! Neither will it depend altogther upon the question of cheapness; for, if the cost of gas light and electric light at all approach, the former must give way to the latter. The one has everything in its favour; the other has very little. Let us consider for a moment the statements made by the ardent supporters of gas. In a pamphlet which has reached a revised edition, Mr. H. M. Backler makes a number of misstatements. Speaking of the Jablochkoff candles, he says: "These carbon sticks are consumed in about half an hour, and must then be renewed. Whilst this

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is being done the light ceases, unless a duplicate candle, previously lighted and kept in readiness, serve as a substitute. At all events, very delicate manipulation is required every half hour." As a matter of fact, the carbons are not consumed in half an hour, nor need there be any cessation of the light; neither is the new candle lighted before the other is out, nor is any delicate manipulation required every half hour. Mr. Backler, as, indeed, do all the opponents of the electric light, speaks of the use of a machine and engine a few hours daily, the work required to get up steam, and the impossibility of turning on the light in an emergency. This is altogether an inaccurate idea of the electric light. Probably, for household purposes, no machine or engine will be required, and the arrangements will be such that the electric light can be turned on and off, very much in the same way as the gas, by turning a tap or plug, which, according to its position, makes and breaks the electric circuit. Suppose, for an instant, that a light of equal intensity to forty ordinary gas burners could be placed in an ordinary room at a cost per hour equivalent to twenty gas burners, it is no drawback to the introduction of such a light that part of its intensity has to be cut off at once by a globe. Yet the fact that part of the intensity is so cut off is used as an argument against it.

But, as we have previously said, it will be many years before this point of extension is reached, and, in the meantime, gas companies will do well to consider Mr. Backler's advice that, in the event of electricity trespassing on their domain, they take over and work the intruder. We must confess that in some cases the heat of gas is of great service, and reduces the expense of fuel considerably, and this point is noted by the author of the pamphlet. Mr. Sugg, whose letter we reprint elsewhere, in his answer to the statements of Mr. E. J. Reed, scarcely deals with the question fairly. A good deal of what he says, however, is worth consideration. We must take exception to such statements, as "it is a well known fact that electric lights cannot safely be left without an attendant constantly watching them." The electric light is so left, night after night, in various places, and, although it occasionally plays pranks and goes out, so does gas; and it is certain that, with as careful attention, in the first place, to the connections in the circuit as is given to the gas connections, the liability of the electric light to give a "dark" surprise will become less and less. The lighting of the streets of Paris was really the first experiment on so large a scale, and it is as ridiculous to decry the prospective utility of such a light as it was to rail against steam when the steam engine was first introduced. Whenever any great improvement has been in its initiatory stage of introduction the same cry has gone forth, but the improvement steadily forced its way till it became a necessity. What we also wish to point out is, that time has always unavoidably been an element in the process.

AN ELECTRIC MACHINE THAT WILL TRANSMIT POWER BY WIRE.

To utilise the vast power generated by numberless rivers and tideways, by transmitting it from regions where not used to points where it is invaluable, has long puzzled scientists. In places away from the seaboard and the great water courses especially, power has heretofore been obtained only by the erection of expensive machinery, the constant generation of steam, and the consequent consumption of vast quantities of coal brought from a distance.

While visiting the mining regions of the Sierra Nevada and Rocky Mountains in his late Western tour, Professor Edison was struck with the difficulty there had by miners in drilling and boring, though in many cases in the vicinity of rapid flowing mountain streams. Except in "placer" mining, where the ore is washed out of the bed or banks of a river, or where expensive steam drills are used, the work of mining is laborious. While watching miners drilling by hand, a means of facilitating this work evolved itself from Edison's fertile brain. Turning to his intimate friend, Professor Barker, of the University of Pennsylvania, he exclaimed, abstractedly, "Why cannot the power of yonder river (pointing to the Platte River on the plain a thousand feet below) be transmitted to these men by electricity?" This thought seemed not to go from Edison's head, and all the way across the plains on their journey home he and his friend "Barky" discussed various problems for the transmission of power.

Before starting for the West. Professor Barker had visited Ansonia, Conn., where his old friend, Mr. William Wallace, is engaged in the manufacture of electrical machines. Mr. Wallace has profound scientific research, and beside the mechanical part of his business, he devotes himself enthusiastically to that part of physics that comprehends electricity, magnetism, and the polarisation of light. He showed Professor Barker an instrument to which he had devoted the best years of his life, but which was yet in a crude condition. He is still experimenting with it, but he believed he would so perfect it as to transmit power from one point to another by means of electricity.

When the Edison party had arrived in New York, Professor Barker bethought himself of the instrument previously shown him by his friend, and which at the time he had only cursorily examined. He invited Professor Edison to visit Ansonia with him, an invitation that was at once accepted. Last Sunday was the day fixed upon. The party consisted of Professors Edison and Barker, Professor Chandler of the Board of Health, and Mr. Edison's assistant, Mr. Bacheller.

It was an agreeable surprise to the party to find that Mr. Wallace had perfected his machine. Being exceedingly modest, and caring not for notoriety, he had shown the instrument to few, and these only persons whose lack of scientific knowledge prevented them from comprehending its usefulness. Mr. Wallace calls it a telemachon, and he smiled with pride as he pointed to a number of these machines, each one an improvement upon its predecessor, and each having required years to design, and nearly $1,000 to construct.

Mr. Edison was enraptured. He fairly gloated over it. Then power was applied to the telemachon, and eight electric lights were kept ablaze at one time, each being equal to 4,000 candles, the subdivision of electric lights being a thing unknown to science. This filled up Mr. Edison's cup of joy. He ran from the instrument to the lights. and from the lights back to the instrument. He sprawled over a table with the simplicity of a child, and made all kinds of calculations. He calculated the power of the instrument, and of the lights, the probable loss of power in transmission, the amount of coal the instrument would save in a day, a week, a month, a year, and the result of such saving on manufacturing.

That a man like Mr. Wallace, after studying privately upon the subject for years, should calmly, deliberately, and without ostentation, bring out before them an instrument calculated to revolutionise the entire manufacturing business, filled the party with amazement.

By means of it power may be obtained from places where river power or tidal power is abundant, or may be generated where fuel is cheap, as at the coal mines, and by means of an ordinary cable be transmitted hundreds of miles. The cable may be tapped at any point and power used therefrom.

Some notion of the stupendous results that may follow, should the telemachon prove completely successful, is given in the opinion of Professor C. W. Siemens, of the Royal Society of Great Britain, who has recently visited this country. In a recent address in Glasgow, he said that in England a means of transmitting power by electricity must soon be the important problem of the day. What are the English people to do when their coal is exhausted? Of America and her great water courses he said:

"The amount of water falling over Niagara is equal to 100,000,000 tons an hour falling 150 feet. The amount of coal required annually to raise such a weight up to the point from which it fell, which is a measure of the amount of power yielded by that water in falling, would require the consumption of 260,000,000 tons of coal a year, which is the amount now consumed by the entire world. Now, if 50 per cent. of the power used to drive the first dynamo-electric machine may be recovered from the second, and hence, if the whole power of Niagara could be utilised, it could be distributed over the United States, so as to give from that waterfall alone power equal to the present entire mechanical force of the world, estimating that one-half the coal used is solely for mechanical purposes."

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As an example how the fall of such a body as the Falls of Niagara could be practically utilised by means of the telemachon, a gentleman who has studied the subject for years gave the following illustration last Sunday:—A series of flumes could be constructed from the edge of the descent of the American falls to the level of the water below of a size sufficient to carry all the water of Niagara river through water wheels. With shafting, this power would be used to turn the machine generating the electric current. This current could then be carried to New York city by conductors, which are copper rods. These rods may be tapped then at any point, wherever power is needed, and wires carried into factories just as gas is now carried in pipes through the streets. In the factory a telemachon would be placed of a power sufficiently great to run the shafting. Thus the entire power required by the State of New York might be taken off along the line of the main conductors. The amount of electricity taken off at any one point would be readily regulated in the same way in which the current taken from a battery for telegraphic purposes is now regulated—that is, by introducing suitable resistance in the local line.

So powerful are the magnets attached to this instrument, that the party, while observing it, were compelled to leave their watches in another room, else they would have been magnetized.

Mr. Edison believes that he can so assist Mr. Wallace in perfecting the telemachon that power may be transmitted from one point to another as though it were a telegraphic message. Already by means of this instrument Mr. Wallace is enabled to transmit the power of the Naugatuck River a quarter of a mile. The power of this stream is great enough to drive the ponderous machinery of the Wallace factory, where 300 men are employed. A series of experiments with the instruments has shown that in the transmission of this enormous power by electricity only 20 per cent. is lost.

In this instrument the electricity is produced by the Wallace dynamo-electric machine, no battery being used. Four large electro-magnets are placed with their poles facing each other. On an axis parallel with and situated between them is a disc of iron carrying upon its opposite faces a row of electro-magnets, thirty in number, on each face, whose poles, facing outward, revolve as close as possible to the poles of the large magnets, called the field of force. On the same axis, but outside of these discs, strips of copper are placed equal in number to the magnets on the discs, each strip of copper being connected to one end of the wire on the magnet. The other end of the wire goes to the next strip. Each strip, therefore, is connected to the last end of the coils and to the first end of that immediately following it. When the disc, with its magnets, is revolved by any power, the weak magnetism remaining in the iron itself generates a current of electricity in the wire surrounding these magnets. In virtue of the principle discovered by Faraday, that whenever a conducting wire is moved in the vicinity of a magnet a current of electricity is caused to circulate in that wire, the feeble current thus generated flows around the magnets of the field of force, increasing their magnetism. This increased magnetism reacts upon the revolving magnets, increases the electric current, and so, alternately, until the magnetism attains a maximum, and that maximum is generated in the wires of the revolving magnets. This current bears for each a perfectly definite ratio to the power consumed, and they are capable of converting eighty per cent. of the power applied into electricity. The electric current generated is carried by two copper wires to a second machine, the telemachon. This effects the reverse operation, that is to say, the re-conversion of the electricity into mechanical power. The telemachon consists of a field of force and a revolving armature. This field of force consists of twelve large electro-magnets in two sets of six each, the poles of each set facing each other, and connected together by heavy bands or bridges. In the space enclosed by these magnets, and parallel with them, is the armature axis supporting an armature consisting of a ring of iron wire serving as a core, round which is wound an insulated copper wire in two series of fifty coils. The ends of these wires come out alternately to the right and left of the armature, and are connected with two break pieces upon their axes. Six springs or brushes of copper wire press upon these break pieces, each pair of brushes facing each other, and opposite a pair of magnets in the field of force. The electric current entering the machine presses round the field of force and magnetizes the magnets. At the same time it passes through the armature, magnetizing that, so that the poles of the armature nearest to the poles of the field magnets are of the opposite name. In consequence of this, the field of force magnets attract the poles of the armature and cause the armature to move. But the motion in its new position brings other portions of the break pieces in contact with the spring, and causes a redistribution of the magnetism. Again attraction takes place as before, and again the direction of the current is changed by the break pieces. The magnetic effect being continuous, the rotation is continuous, increasing constantly in speed until the friction and the magnetic power balance each other. In Sunday's experiment the hodemeter showed that the machine made 3,000 revolutions a minute.

The electricity from the wonderful telemachon may be applied to illumination. It solves the problem of the sub-division of electric lights. Both the Wallace Foundry and the Farrel Foundry, near by, are lighted by these lights, the army of men being formed in two divisions, one working during the day, and the other up to midnight. Thickly studded as these foundries are with heavy machinery, and obstructed as the light must necessarily be by the ponderous cranes, drills, supporting columns, and projections, a clear light is thrown upon the machinery, perfectly illuminating it. Adjustments to the thirty-second of an inch may be made without the least strain upon the eyes. A beautiful effect of this light is its polarisation—that mottled appearance which it assumes when falling through glass. This is the only artificial light, it is said, that is capable of producing it.

The following is an estimate, made by an expert, of what it would cost to light the streets of New York with these lights: The average street burner gives a light equal to ten candles. Assuming that one of the eight electric lights produced by the power of one machine is equal to 4,000 candles, and assuming that there are 5,000 lamps, each lamp burning 20 cubic feet of gas an hour, at a cost of $1 a thousand feet, it would require 12½ of these machines to furnish all the light required. The cost of the gas by this rough estimate would be $100 an hour. To produce the same light by electricity would require, say, thirteen machines, placed upon towers. The cost of a single light equal to that of 1,000 candles would be three cents an hour. Each machine giving 4,000 candle-lights would cost, therefore, twelve cents an hour, and thirteen would cost $1·56 an hour.—*N. Y. Sun.*

ELECTRIC LIGHTING.*

SIR: Your correspondent, Mr. E. J. Reed, in his letter published in yesterday's issue, gives a copy of a statement of the cost of electric lighting as compared with ordinary gas lighting, extracted, he says, from a paper by M. Hippolyte Fontaine, of Paris, published in the proceedings of the Institution of Mechanical Engineers.

From the commencement of the observations of Mr. E. J. Reed, who says he has closely observed the progress of electric lighting, I was led to believe that the promised statement of comparative cost applied to the process of Jablochkoff; the more so as he says it appears to him that all statements of cost made previously to Jablochkoff's invention must be entirely fallacious. Why so, does not clearly appear, any more at the end of his letter than at the beginning.

The statement of cost applies, as any one who is acquainted with the details of electric lighting can easily perceive, to that system which M. Fontaine, and, indeed, a great many other practical electricians, believe to be the simplest, cheapest, and best adapted for electric lighting, viz., one light upon one magneto-electric machine, the current in one direction, and a Serrin regulator with vertical carbons. Neither of these is an invention of either M. Jablochkoff or M. Rapieff. The magneto-electric machine is Gramme's, the Serrin regulator is the well-known instrument manufactured by Breguet and others. The mode of lighting is the same as that which has been in use now for many years at the South Foreland lighthouse, Holme's machine being there used instead of Gramme's. The Dover lighthouses have the enormous advantage over the systems of electric lighting at present proposed for lighting streets and public buildings from having magnificent Fresnel lanterns, which refract every ray of light, and convert in the most perfect manner intensity of light into volume of light. This real triumph of science leaves far behind anything which has yet been done to attain the same result by other means.

An examination of the statement of cost shows that, although put in evidence by M. Fontaine, for whom every one who knows him must entertain the highest respect, it must be classed with those statements anterior to the inventions of Jablochkoff and Rapieff, which Mr. E. J. Reed thinks fallacious. I think M. Fontaine, after looking over my remarks, will be inclined to make a re-examination of the statement. Assuming this statement to be correctly copied, I have first to remark that 6 per cent. for depreciation is certainly not enough for a magneto-electric machine making from 1,000 to 1,100 revolutions per minute. It is true that so long as the bearings of the "Bobine" are kept in order there can be no rubbing between the "Bobine" and the electro-

* This letter appeared in *The Times* in answer to the one of Mr. E. J. Reed, which we quoted last week.—ED. E.

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magnets; but, taking fair wear and tear and the probability of accidents to the machine through being improperly driven, 16 years is too long a life for a magneto-electric machine, without very extensive repairs and renewals of parts of the machine—notably the copper brushes for taking off the electricity. The Serrin regulators, very delicate and fragile instruments, are also classed with the magneto-electric machine at the same rate of depreciation. This item of depreciation must be reckoned at 10 per cent. at least. This will give us on 588*l.* for Gramme machines, Serrin regulators, and conductors, the sum of 58*l.* 16*s.* per year.

Shafting and driving belts are classed at the same rate of depreciation—viz., 6 per cent. The real depreciation of these parts of the apparatus is at least 15 per cent., or on 87*l.* 6*s.* 9½*d.*, 13*l.* 2*s.* per year.

Driving power estimated at only 30*l.* per year, for 15-horse power at 11*d.* per hour, for only the actual number of hours the electric light is being used, is evidently an error—*i.e.*, unless some ardent admirer of the electric light gave the power for a nominal consideration for the sake of science. The cost of a 15-horse power engine and boiler in its cheapest form is 250*l.* M. Fontaine gives as the consumption of fuel for 15-horse power, 4½*d.* per hour (and exceedingly cheap too); this, for 600 hours, amounts to 15*l.*, without any charge for water or for fuel used in getting up steam. The cost of an attendant, at 1*l.* only per week, to look after the engine and boiler amounts to 50*l.*; interest on cost of engine and boiler at 6 per cent., 15*l*.; depreciation of engine and boiler 10 per cent., 25*l.*; or a total amount of 105*l.* per year for driving power.

In the next item—viz., carbons for six lights—according to my experiments, with probably the identical kind employed by M. Manchon—Carré's carbons—I find that, including breakage and waste, one metre per hour is not too much. Taking Carré's printed list, I find he charges 1f. 80c. per metre in length, exclusive of carriage; 1*s.* 6*d.* per hour for 600 hours gives 49*l.* 10*s.* for this item.

Superintendence and maintenance of the magneto-electric machines and their lamps or regulators, conductors, &c., figure in the working cost at only 13*l.* 4*s.*, or only 4¾*d.* per hour for the number of hours the lights are burning. Now, it is a well-known fact that electric lights cannot safely be left without an attendant constantly watching them. At any moment they may be extinguished without any visible cause. This cause of extinction must be searched for immediately by a competent person. The supply of new carbons and the adjustment of the regulators, together with the care of the expensive magneto-electric machines and regulators during the whole time they are at work, necessitate the employment of a steady, strong-nerved mechanic, used to electricity and clockwork. Such a man will cost, at least, 2*l.* per week, and the time he is not attending on the lights will be fully employed in keeping the lamps and magneto machines, conductors, and binding screws, and all the apparatus clean and in decent order. This item for 50 weeks will be 100*l.*

Lubricating oil for the six machines and all the machinery is estimated at the trifling cost of only ½d. per hour. Excepting for the sake of appearances, I think it might have been left out altogether. If this item is to be seriously considered as correct, then it is astonishing. The working cost of the electric lighting thus corrected will be as follows:—

Electricity.

	£	s.	d.
Interest 6 per cent. on 912*l.* 8*s.* 4*d.* (given by M. Manchon as "first cost")	£54	14	10½
Depreciation of 6 Gramme machines and 6 Serrin lamps, conductors, &c., at 10 per cent., on 588*l.* ...	58	16	0
Depreciation of shafting and driving belts, 15 per cent., on 87*l.* 6*s.* 9½*d.*	13	2	0
Driving power, 15-horse power, fuel, attendance, and depreciation, without charge for water, at least ...	100	0	0
Carbons for the six lights, one metre per hour, including waste—1f. 80c. per metre = 1*s.* 6*d.* per hour for 600 hours	49	10	0
Superintendence and maintenance of the machine by one man at 2*l.* per week, say 50 weeks	100	0	0
Lubricating oil, ½*d.* per hour	1	13	7½
	£377	16	6

Or, 377*l.* 16*s.* 6*d.* divided by 600 hours gives 11*s.* 5*d.* per hour for electric light.

My experiments, by diagram taken from the engine while the lights were burning, show that the force required for one electric light, such as can be produced by a Gramme machine of the pattern here mentioned, is from four to five horse power. This is corroborated by observations that I have made in Paris upon three such machines at work regularly. It is necessary to note that the engines and shafting used to drive the magneto-electric machines are always, as I have seen them driven, working at a high rate of speed—engines going from 130 to 150 revolutions per minute, with a pressure of steam equal to 30lbs. on the square inch. Engines thus driven ought not to be spoken of as though they were working at their nominal horse power. Comparing this statement with the statement of cost of lighting by gas, taking the figures as printed, we find that the cost of gas is considerably lower than that of electricity—viz., 7*s.* 6¼*d.* per hour for gas as against 11*s.* 5*d.* per hour for electricity. It may be remarked that 1½*d.* per hour for the breakage of such glass shades as are used in factories is rather severe on the gas. This is in France, with gas at 7*s.* 2¼*d.* per 1,000 cubic feet.

With 16-candle gas at 3s. 6d. per 1,000 cubic feet, as supplied to the city of London, the estimate for gas will be as follows:—

London Gas.

	£	s.	d.
Interest and depreciation, 12 per cent. on 253*l.* 6*s.* 8*d* (taking the figures given by M. Manchon as the "first cost")	£30	8	0
Consumption of gas at 3*s.* 6*d.* per thousand	101	10	7
Repairs	8	0	0
Glass shades	4	0	0
	£143	18	7

Or, 4*s.* 4½*d.* per hour.

These comparisons of the cost of the two modes of lighting are made with electricity in a highly scientific, though simple and cheap, form of application and gas in a crude and unscientific form. If the gas had been consumed in a scientific manner with the best form of burners, in lights equal to 100 candles each, properly distributed, the effect in light would have been far greater and more convenient for the work than when burnt in the unscientific manner which usually obtains in factories and large buildings.

The electric light is, doubtless, useful for many purposes; but there are great practical difficulties to be overcome before it can take the place claimed for it by its too enthusiastic admirers. As a scientific light it deserves attention, and in places where it can be used properly, and all its advantages developed, no other mode of lighting will be likely to be preferred to it. But as a general mode of lighting it is eminently unsuitable. The difficulty of transforming its great intensity into volume of light is in the way of its adoption where cost is regarded. The subdivision of the electric current into many small lights, instead of a few large ones, only increases the difficulty in greater proportion as the lights become smaller. But in any case it can only succeed in replacing other systems of lighting by being superior to them in regard to steadiness, constancy, readiness, and ease of application, softness and volume of light, together with cheapness.

I am carrying out a series of experiments with a view to ascertain its practicability as a means of lighting and its cost, and I shall be very pleased to afford you fuller information as to these matters in a short time as the experiments proceed.

I have the honour to be, Sir, your most obedient Servant,

William Sugg.

Vincent Works, Vincent-street, Westminster, S.W.,
October 10.

CORRESPONDENCE.

EDISON AGAIN!

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Mr. Edison has now discovered, as you are all well aware, a simple method of applying electrical forces to domestic purposes as a motor for working a lift, turning a sewing machine or mangle, superseding carburetted hydrogen (vulgarly called gas), and for supplying heat. Acting as his agent, I beg to reassure the British public, whom it specially concerns, that with regard to the last named item, although it is his intention to do away with coals and all manner of fuel, fireplaces will still be utilized. You need only "touch a spring" and the stove or grate will—as computed by Mr. Edison, with his cuscustomary exactness—in the space of 121 seconds attain a glow of heat 2·009 times more intense than that obtainable with the best Wallsend. Nor will this drain upon the electrical current in the least diminish the power at the householder's disposal for mechanical and lighting purposes. A constant supply will be laid on at annual rentals 50 per cent. less than the price of "carburetted hydrogen," whatever its price may be.

I may also mention that steam engines will in future be self-sustaining. The telemacon once started, by means of a handle (patented), it will generate electricity and heat sufficient to get up steam and keep the machinery going. As no coke or coals

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will be used, and as water will be made as required by the combination of gases, electrically, it is thought that in the case of railways the locomotive may be carried in the guard's van.

To the one or two British editors who are still incredulous and confront Mr. Edison's notions with "the laws of energy," I have only to say that we know nothing about those laws at Menlo Park. All we have to concern ourselves with are the *Patent Laws*; and I guess we know them so well that, if any scientific Britisher discovers—or has already discovered—anything useful in the way of electric lighting he will, after this notification, be guilty of piracy if he publicly claims it as his own.

I am prepared to receive orders (accompanied by a preliminary fee) for all Mr. Edison's inventions; and I don't object to gas shares at present values to oblige intending customers.—Yours, cruelly, I. FLYER.

THE PHONOGRAPH.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Being desirous of obtaining the above instrument, I should be glad if you or any of your readers could give me information on the following points:—

1. Where can I obtain a phonographic apparatus complete?
2. Can I obtain the necessary metal plates already indented with musical sounds, and ready for their reproduction?
3. What would be the cost of the phonograph and of the plates?
4. Is the phonograph liable to get out of order?
5. Is any previous technical knowledge necessary to work the phonograph?

I am, Sir, your obedient servant,
ONE INTERESTED IN THE INVENTION.

6th October, 1878.

THE RAPIEFF SYSTEM.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: One of my French correspondents states that a Russian inventor, Monsieur Rapieff, is now making experiments in London on electric illumination, and that his efforts at improvements have been attended with some success. I cannot, however, obtain any particulars, and shall feel obliged if you, or any of the readers of your much esteemed paper, can afford me information on the subject. FIAT LUX.

7th October, 1878.

SOCIETY OF ENGINEERS.

OCTOBER 7TH, 1878.

ROBERT PAULSON SPICE, President, in the chair.

The following paper, "On the Application of Electricity to the Ignition of Blasting Charges," was read by Mr. G. G. André, F.G.S.:—Among the numerous applications of electricity to industrial purposes, the ignition of blasting charges for the removal of rock is not the least important. The great advantages to be derived from electrical firing have long been known, and are now generally acknowledged. To obtain these advantages by devising a system which shall be easily applicable, and suitable to the various conditions that occur in practice, persistent efforts have been made during many years past by several eminent men in this country and abroad. These efforts have been crowned with a certain degree of success; but it cannot yet be said that a thoroughly efficient system has been obtained. The progress made, however, has been such that we may fairly hope to see the difficulties fully overcome in the immediate future. In order to clearly understand the nature of these difficulties, and to appreciate accurately the progress made, it will be necessary to consider, first, what the requirements of practice are, and what are the conditions under which those requirements have to be met.

The advantages obtained from electrical ignition are of two kinds, namely, those due to the simultaneous discharge of the blasts, and those which follow from the nature of the means of ignition. Simultaneous firing obviously lessens the total amount of work to be done by the explosive agent employed. As an illustration, suppose a free rock face, A B, Fig. 1, behind which are three shot-holes *a, b, c*. If *a* be fired first, the lines of fracture will run in the directions *a, m, a, n*, and a wedge-shaped piece *a, m, n*, will be blown out. The subsequent firing of *b* will cause the lines of fracture to run in the directions *b, o, b, p*, and will force out a trapezoidal block *b, o, n, p*, leaving a boss *a, b, o*, and the explosion of the shot *c* will subsequently, and in like manner, by causing the lines of fracture *c, q, c, r*, bring out the block *c, q, p, r*, and leave the boss *c, b, q*. But if these three shots be fired simultaneously, the lines of fracture will run in the directions *a, m, c, r, a, c*. In this case, the lines of fracture are much shorter than in the preceding; there is, therefore, less work to be done, and consequently a smaller quantity of explosive will be required. Thus there is an advantage on the side of economy obtained from the simultaneous firing, and it is evident that this advantage will increase in importance with the number of shots fired together. But it will be observed that this simultaneous firing leaves no projections or bosses, the face being brought away comparatively clean and smooth. This is another advantage of no small importance. Also, by firing the shots at one instant there is a saving of time, which in many cases may be of some importance.

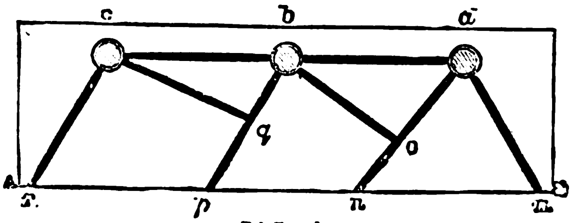

FIG. 1

Of the advantages which follow from the nature of the means of ignition employed, the greatest is, perhaps, the increased safety of those engaged in the blasting operations. The fuses in the several shot holes having been connected together, and put into the circuit formed by the leading and the return wires, the men retire for the blasts to be fired, and by no possibility can the explosion take place until they have withdrawn to the place of refuge provided. With safety fuse it is otherwise. The fuse is ignited in the presence of at least one man, and the burning continues during the time that he is hastening away. Should the fuse, or one portion of it, prove defective and "run," as it is termed—that is, burn too rapidly—the chargeman is exposed to great danger; but, with the electric fuse, the blast is fired at the precise moment desired, when it has been ascertained that all are under shelter. It will need but little reflection to see that this condition is one which is highly conducive to the safety of those employed. But the majority of accidents in blasting are due to the missed shots, or rather to shots that are erroneously supposed to have missed. Not unfrequently the continuity of the gunpowder train in a piece of safety fuse is interrupted, and the burning ceases at that point. But in such a case the covering will smoulder like touch paper until it has again started the train beyond the point of interruption. The operators, believing the shot to have missed, return to the working face only to be blown to pieces by the unexpected explosion of the charge. Against this danger electricity affords perfect security, for, if a shot fails to explode when the current is sent through the circuit, by no possible chance can it explode afterwards. Thus the advantages on the side of safety are greatly in favour of electrical firing.

But there is also a notable gain of speed due to the same cause. From fifteen to twenty minutes are allowed to elapse before the men return to a missed shot. Now, though hangfires and missfires, due to defective manufacture, are not of very frequent occurrence when fuse of good quality is used, missfires, occasioned by the fuse being severed by the explosion of an adjacent shot, are, in close headings and shafts, every day events. By waiting the prescribed time much delay is occasioned. This delay is entirely avoided by the use of electricity, for then the missed shot may be approached at once. When a large body of men are employed, and when speed is a primary requirement, this advantage is an important one. There are other minor advantages attending the use of electricity as a means of ignition. One of these is the possibility of igniting the charge in the middle, a mode of firing which, with dynamite especially, gives the best results. The common kind of safety fuse will not carry the fire into the charge because the covering burns through. A remark may here be made on certain accidents which have lately occurred with dynamite. The Government inspectors, Majors Majendie and Ford, after a careful investigation of the circumstances attending these accidents, have come to the conclusion that they are due to the exudation of nitroglycerine from the dynamite, this exudation being occasioned by the presence of water in the bore holes. Setting aside the improbability of a sufficient quantity of oil exuding and escaping ignition by the blast to produce the disastrous results in question, the author's experience has led him to a different conclusion. It is no uncommon occurrence, especially in bore holes tamped with water, for a portion of the charge to be left unexploded at the bottom of the hole. When boring is recommenced in these "bottoms" or remaining portions of bore holes after the blast, the first few strokes of the drill cause the unburned dynamite to detonate. This source of accident would be removed by placing

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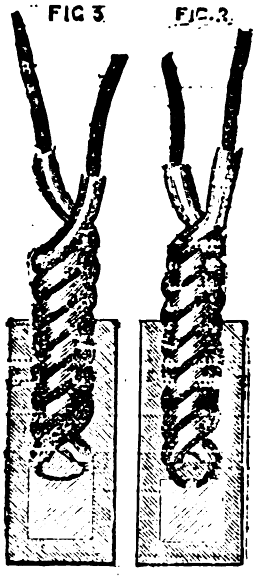
the detonator at or near the bottom of the hole. Thus, generally, electricity affords the most convenient, the most effective, and the most safe means of firing blasts. For subaqueous operations and for large blasts it is particularly suitable.

The Austrian chief inspector of railways, Hofrath Ritter von Pishoff, thus expresses himself concerning the advantages of electrical firing:—"A greatly increased amount of work and a notable saving of cost is effected when the shots can be so disposed and fired as to mutually assist one another. These results are obtained by the use of electricity as the firing agent. The experience which has been gained at the Buckenberg cutting, where the method of firing by electricity has been extensively adopted, has shown that, when properly employed, this means allows, in comparison with the ordinary methods, twice the amount of work to be performed in a given time. It is therefore strongly recommended to adopt electrical blasting whenever it is a question of economy of time and of money."

The requirements of practice may be summarised as follow:—(1) Electric fuses should be so constructed as to be easily applicable to the charge of explosive used. (2) They should not be capable of being injured by rough handling. (3) They should be so prepared that the operator may have no trouble or difficulty in putting them into circuit. (4) They should be certain to explode under ordinary conditions of firing. (5) They should explode simultaneously in large numbers.

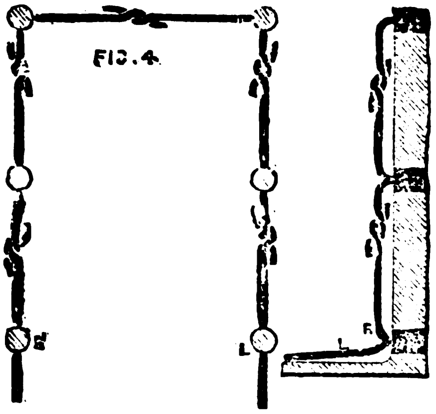
There are two kinds of electric fuses in use, known respectively as "tension" and "quantity" fuses; because the former are fired by means of a current of small quantity of high tension, and the latter are fired by means of a current of large quantity and low tension. In tension fuses the priming composition is

FIG 3. FIG. 2.



fired by the passage of a current of electricity through it. The circuit is interrupted within the casing of the fuses, and the priming is interposed in the break (Fig. 2). The current, in leaping across the interruption, meets with great resistance from the low conductivity of the substance to be passed through, and, consequently, heat is generated and the priming is fired. To overcome the great resistance occasioned by the break in the metallic circuit, high tension is required in the current, which must therefore be generated by a machine, the low tension current of a battery being insufficient for the purpose. These fuses can, however, be fired by batteries of great power, by reason of the conductivity of the priming composition. In quantity fuses the priming is fired by the heat generated by the current in a piece of fine platinum wire. This wire is included in the circuit, and surrounded by a substance inflammable at a low temperature (Fig. 3). The heat developed in the wire is due to the great resistance occasioned by its small section. As the circuit is uninterrupted, the low tension current generated by a battery, or by a dynamo-electric machine constructed for quantity, may be used. The advantages of high tension lie chiefly in the convenient form and ready action of the machines employed to excite the electricity. Being of small dimensions and weight, simple in construction, and not liable to get quickly out of order, these sources of electricity are particularly suitable for use in mining operations, especially when the operations are entrusted, as they usually are, to men of no scientific knowledge. Moreover, as the means of discharging the machine may be removed until the moment when it is required, this mode of firing offers greater security than the battery. Also by employing a current of high tension, a large number of shots may be fired simultaneously in single circuit with greater certainty than is obtained with a battery. Another advantage of high tension is the small effect of line resistance upon the current, a consequence of which is that mines may be fired at any distance from the machine, and through iron wire of very small section. The disadvantages of high tension are the necessity for perfect insulation of the wires, and some degree of uncertainty in the fuse when not properly constructed. When electricity of low tension is employed, the insulation of the wires needs not to be perfect, so that leakages arising from injury to the coating of the wire are not of great importance. In many cases bare wires may be used. Another advantage of low tension is the ability to test the fuse at any moment by means of a weak current, whereby an almost absolute certainty of action may be insured.

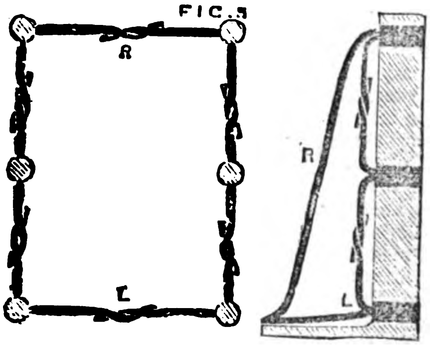
FIG. 4.



For this reason it is usually preferred for torpedoes and important submarine work. On the other hand, the copper wires used must be of comparatively large section, and the influence of line resistance is so considerable that only a small number of shots can be fired simultaneously when the distance is great. Moreover, as the number of fuses is increased, the power of the battery must be augmented by adding to the number of its cells, so that for ordinary mining operations the battery becomes large and unportable. But the chief disadvantage of the battery lies in the fact of its requiring a liquid to excite the current, and the consequent careful attention and delicate handling which the elements require. This defect may, however, be removed to some extent by a suitable form of the battery.

Baron von Ebner, of the Austrian military service, was the first to construct a tension fuse that was at all satisfactory in its action. It did not, however, fully satisfy any one of the requirements laid down in this paper. It was clumsily constructed, and was only fairly certain in its action. But it must be acknowledged to be the model upon which all subsequent inventions have been founded. Professor Abel, in this country, took Ebner's construction, and primed it with a new powder of his own invention. This fuse, known as "Abel's fuse," has been largely used for firing guns and for military purposes generally, but the mode of construction adopted and the cost of production have prevented it from being much used in industrial operations.

FIG. 5



Mr. Beardsley, in the United States, introduced a new system by interposing a bridge of graphite between the terminals within the fuse, the graphite being heated by the passage of the current, and the priming resting upon the graphite thereby fired. This fuse is very certain when fired singly, and it is capable of being tested like a platinum wire fuse, but when connected in large numbers they fail.

During the last ten years several modifications of the foregoing fuses have been adopted in practice in Germany, in the United States, and in this country. Some of these, especially the American invention, fulfil the first four requirements; but none fulfil the fifth. If the number in circuit be not greater than ten, the best of these fuses may be relied upon to explode. But when

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this number is exceeded, some of the fuses miss. The cause of these failures has not been satisfactorily ascertained. If we put two fuses in single circuit, as shown at Fig. 4, and one of these has much greater conductivity than the other, this one will miss. If they are put in divided circuit, as shown at Fig. 5, the other one, that is, the fuse which has least conductivity, will miss. If both fuses are practically equal in conductivity, both will explode. From these facts it has been inferred that if all the fuses were equal in conductivity, any number within the power of the machine could be fired at once. The inference, however, is not true. The author designed an arrangement by means of which fuses can be made almost exactly equal in conductivity. If the number in circuit be limited to fifteen or sixteen, they all explode with certainty, but when the number is greater, failures occur. In searching for the cause of these failures, it would be seen that time must be taken into account. The resistance of the fuses retards the current, and possibly the explosion of the first may interrupt the circuit before the current has acted sufficiently on all. It should be remarked here that no better results are obtained by putting the fuses in divided circuit. The author has, after many disheartening failures, brought into use a fuse which fulfils completely the first four requirements, and which satisfies the fifth up to fifteen or sixteen in circuit at one time. With this number the face of a heading or the bottom of a shaft may be brought away in two blasts.

Since Mr. Fox read his paper before this Society on "Lighting Gas by Electricity," the author has conceived a new arrangement, by which he hopes to succeed in firing any reasonable number of fuses at once. This arrangement is based on the fact that fuses will fire singly with absolute certainty. The author has proved this by firing 10,000 without one failure. There is, therefore, good reason to believe that thirty of Mr. Fox's small and inexpensive coils, neatly arranged in a box, and placed at a safe distance from the shots, would fire with certainty thirty fuses, because each coil would have its own fuse; in other words, they would be all fired singly.

With regard to missfires, a word of protest may be raised. An occasional miss with safety fuse, which causes delay and creates danger, is looked upon with unconcern, and spoken of as a thing to be expected; but if 1 per cent. of the electric fuses fail, though no danger is incurred by immediately returning to the spot, the system is at once condemned. Moreover, the failures are in nine cases out of ten due to the ignorance or carelessness of the operator himself. The author has fired upwards of 20,000 of his own fuses, in groups varying in number from ten to sixteen, and under all the conditions that can occur in practice, without one missfire. This fact is sufficient to prove that the source of failure is to be looked for in the man rather than in the material he uses. Attention is required to keep the machines in order, and it is here that neglect is most commonly observed.

When frictional machines are used, the fuses must be connected in what is known as "series," or single circuit. In this arrangement, which is shown in Fig. 4, the whole current is sent through the series of fuses. With dynamo-electric machines it is better to adopt the divided circuit as shown in Fig. 5. The leading and the return wires are attached to the groups of fuses at L and R, and the current then divides itself, a portion passing through the fuses to the right of L, and another portion through those to the left of that point. A few words in conclusion concerning machines. Frictional machines act very well as exploders as long as they are kept in a proper state. But as they are injuriously affected by a moist atmosphere, and weaken rapidly with use by reason of the wearing away of the rubbers, it is necessary to take care that they be in good electrical condition before using them for firing. Unless this care be taken the quantity of electricity excited by a given number of revolutions of the plate will be very variable, and vexatious failures will ensue. If, however, the proper precautions be observed very certain and satisfactory results may be obtained. In Germany and in America frictional exploders are generally used. Magneto-electric machines possess the very valuable quality of constancy. They are unaffected in any appreciable degree by atmospheric changes, and they are not subject to wear. These qualities are of inestimable worth in an exploder used for ordinary blasting operations. Moreover, as they give electricity of a lower tension than the friction machine, defects of insulation are less important. Of these machines only the dynamo varieties are suitable for industrial blasting. It is of primary importance that an exploder should possess great power. The mistake of using weak machines has done more than anything else to hinder the adoption of electrical firing in this country.

As will be seen from our advertising columns, the ordinary general meeting of the Brazilian Submarine Telegraph Company (Limited), will be held on Friday next, at the Cannon-street Hotel.

RECENT PATENTS.

471. Carbon Electrodes, *M. Gray.—Dated 5th February*, 1878.—*(A communication.)—(Not proceeded with.)* 2d.

To avoid the useless burning away of the carbon, the surfaces of the carbon pieces are coated with some refractory metal, such as nickel or iron.

492. Battery Rheostats, *S. G. Coxeter.* — *Dated 6th February*, 1878. *(Not proceeded with.)* 2d.

Holes are drilled in a block of wood, and receive various electrical resistances composed of a mixture of graphite and powdered glass, placed in glass tubes. The holes are closed at the upper part by metallic plugs, and at the lower part the whole is covered by a metallic plate, to which they are connected. An arm to form a connection is provided and acts upon the plugs, so that as the arm comes in contact with them, various electrical resistances are interposed when used in connection with batteries.

TELEGRAPH SHARE LIST.

Companies.	Closing Prices Oct. 16.		Business Done Week Ending Oct. 16. Highest.	Lowest.
Anglo-American	58,	½	60	58½ x div.
Do. Preferred	86½,	87	89½	86¾ x div.
Do. Deferred	31½,	32½	32½	31½
Brazilian	6½,	¾	6 13-16	6⅝
Cuba	8¾,	9¼	8¾	8½
Do. Ten per Cent. Preference	15½,	½	—	—
Direct Spanish	2,	½	—	—
Do. Ten per Cent. Preference	10,	½	—	—
Direct United States	12⅜,	⅝	12⅜	12⅜
Eastern	7 1-16,	3-16	7⅛	7 1-16
Do. Six per Cent. Debenture	107,	110	—	—
Do. Five per Cent. do.	99,	101	—	—
Do. Six per Cent. Preference	10⅞,	11⅛ ex div.	11⅛	11
Eastern Extension	7,	½	7⅛	7 ex div.
Do. Six per Cent. Debenture	106,	109	108	103
German Union	7¾,	8¼	—	—
Globe Telegraph and Trust	4¾,	5 ex div.	5⅛	5½
Do. Six per Cent. Preference	10½,	½ ex div.	10⅝	10½
Great Northern	7⅞,	8⅛	—	—
Indo-European	20,	21	—	—
Mediterranean Extension	2½,	3	—	—
Do. Eight per Cent. Preference	9,	½	—	—
Reuter's	10,	11	—	—
Submarine	215,	220	220	220
West India and Panama	2,	½	2 3-16	2 1-16
Do. Six per Cent. Preference	8⅜,	⅞	8⅜	8⅝
Western and Brazilian	2⅝,	⅞	2⅝	2½
West. Union Seven per Cent. 1st Mortgage	114,	118	—	—
Do. Six per Cent. Sterling	101,	103	—	—

TRAFFIC RECEIPTS FOR SEPTEMBER, 1878.

Companies.	September, 1878.	September, 1877.	Increase.	Decrease.
Eastern Telegraph Company	£33,169	£35,440	£2,729	—
West Coast of America Telegraph Company	2,200	1,625	575	—
Cuba Submarine Company	2,600	2,466	134	—
Brazilian Submarine Company	10,463	9,357	1,106	—
Direct Spanish Telegraph Company	1,048	812	236	—
Great Northern Telegraph Company	15,778	18,445	—	2,667
Anglo-American Telegraph Company	44,310	43,230	80	—
Direct United States Telegraph Company	14,770	15,940	—	1,170
Eastern Extension Telegraph Company	22,151	22,113	33	—
Submarine Telegraph Company	9,660	10,029	—	1,369
Western and Brazilian Telegraph Company	—	9,504	—	—
West India Telegraph Company	3,792	3,800	—	8

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NOTES.

Division of the Electric Light.—M. Arnaud, of Blackfriars'-road, has patented an invention which we have seen in operation. As yet, however, we have not obtained any information regarding the details, but the light is obtained by the well known method of inserting strips of platinum in the circuit.

The Electric Light in the Provinces.—The Lighting Committee of the Barnsley Town Council recommend that, on account of the high prices charged the corporation for gas supplied to the public lamps, the Council be asked to consider whether some other mode of lighting could not be adopted. The resolution was passed.

The Rapieff Electric Light.—We have received from the manager of the Electric Lighting Works, Abchurch-lane, two photographs of the Rapieff Regulator, some successful trials of which have recently been made. We hope very shortly to give some details of this invention, and the results of our own examination of the light.

New Form of Leclanche Battery.—The new battery, with depolarising plates formed of an agglomerated mixture of carbon and peroxide of manganese, is now manufactured of three different sizes, the price in Paris varying from 3fr. 75c. to 6fr. We do not hear it very favourably spoken of, in comparison with the old form of this battery, by those who have experimented with it in this country.

Electric Light.—Some of the talent at work on the electric light might, perhaps, with advantage to itself and to the community, be devoted to trying the effect of platinised or iridiumised asbestos or pipe-clay in the circuit. By this means it seems to us that a simple and economical light for household purposes might be obtained. A good deal remains to be done with iridium, its alloys and compounds, alumina and the silicates.

The Electric Light in Chancery.—Mr. Justice Lush refused, on the 22nd inst., to continue the injunction granted last week, at the suit of Mr. Wilde, against Messrs. Wells and Company, respecting the electric light, which had stopped, as alleged, the defendants' experiments for the Metropolitan Board and the City of London. The refusal of the continuance of the injunction was without prejudice to the plaintiffs applying again upon notice, the defendants undertaking to keep an account.

Condensers and Electric Lighting.—The hint that Mr. Fox indulges the readers of *The Times* with is by no means new. A large number of electricians have been carefully reasoning out the action of condensers to be employed in distributing the current, in dividing the current, and in storing it. There is no doubt about the ability to store electricity like gas, and to use natural forces in its development; but the storing at present is a question of such enormous expense as to render it out of the question for practical use.

Telegraphic Communication with Cyprus.—The Eastern Telegraph Company announce the extension of their submarine system to Cyprus. The cable has been successfully laid by the Telegraph Construction and Maintenance Company between Alexandria and Larnaca, and was opened for traffic on the 18th instant. This puts Cyprus in direct telegraphic communication with Malta, Gibraltar, and England, also with France, Italy, Greece, and Constantinople, and, on the other side, with Egypt and India. This company's recent extensions to Besika Bay, Crete, Constantinople, and Cyprus. have been established by agreement with Her Majesty's Government, and are worked throughout by telegraphists under the company's control.

Whitechapel and the Electric Light.—On the subject of the electric light exhibition on the premises of Messrs. Wells and Co., of Shoreditch, the Committee of Works reported that they had discussed the matter with the surveyor, Mr. Iron. The surveyor intimated his desire to have leave of absence for four or five days to visit Paris. He explained that it was his intention and desire while there to procure information as to the electric light in use in the Paris Exhibition, and it was resolved that the required leave of absence be granted, and that the surveyor be requested to obtain such information with regard to the use of the light as opportunities may afford.—On this recommendation being submitted to the full Board, it was adopted amid general laughter.—*Metropolitan.*

The Resistance of the Voltaic Arc.—This resistance has been stated to be between 30 and 40 ohms. In the careful experiments recently made by Messrs. Houston and Thomson for the Franklin Institute committee, the resistance between the carbon points was, however, found to vary from nearly two ohms to less than one ohm—this resistance, in the case of the light obtained with Gramme's machine being 1·87 ohms. It is probable that the resistance of the voltaic arc varies within wide limits according to the resistance and the electromotive force of the electromotor used to obtain the light. Perhaps, some of our readers may have measured this resistance under various conditions, and may thus be able to give information on this point. (Since the above was written, we have received a very interesting communication on this subject from Professors Ayrton and Perry. We should have been glad to know the intensities of the lights in standard candles.)

The Wallace Lamp.—In connection with the Wallace-Farmer machine, Messrs. Ladd have introduced the Wallace lamp, which is exceedingly simple, and, for many purposes, an admirable lamp. It consists of two parallel plates of thin carbon. The carbons, instead of being placed vertically, are horizontal, and when no current passes the edges of the carbons are in contact. The lower carbon is fixed, the upper is connected to a suitable electro-magnet. When a current passes, the magnet acts upon an iron armature, and draws the top carbon upwards, thus separating the carbons. The distance of this motion can be regulated so as to give the best distance for the electric arc. The action of the carbons is easily understood. Being in contact at the moment the current is turned on, the light is generated, and the motion given to the upper carbon determines the length of arc. The carbons burn backwards and forwards, keeping the arc under all circumstances at its normal length. The objection to the lamp is that you obtain no focus of light. It is constantly moving; but this is a minor defect. We have here really a Jablochkoff candle, lying horizontally, with air as the insulator instead of kaolin. The lamp can be hung up anywhere, and, with suitable carbons, gives a good, steady light.

Cobalt-plating.—Mr. J. Wharton contributes the following letter to the *Engineering and Mining Journal* of New York:—"About eight years ago, when talking with a plater, who complained of the Adams patents upon nickel-plating, I suggested that he should try cobalt-plating, upon which no patent existed, as the field was a new one. He was very willing to undertake it, but was at a loss to procure the materials, which, however, I furnished to him, namely, a

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cast-cobalt anode and some cobalt-ammonia sulphate. Shortly after, it occurred to me that, possibly, improper use might be made of my information, and I offered to file in the Patent Office a caveat concerning cobalt-plating. Notice of an interference was returned to me, and it proved that the partner of my interlocutor had promptly applied for a patent for cobalt-plating upon the plan which I had communicated. That gentleman was obliged when testifying in the case to fix the date when he made his discovery or invention, and he named a convenient date, about ten or fifteen years earlier, whereupon my attorney exhibited a German book, printed several years before that date, in which the process was sufficiently described. Of course, no patent was granted, but several years later *the same gentleman applied again for a patent for cobalt-plating, and obtained it;* he still enjoys it, if that term may be used, for nobody has taken the trouble to contest it. So much for our patent system. Now, as to the merits of galvano-plating with cobalt, I believe it has no advantage over nickel-plating to compensate for its greater cost, except that cobalt is whiter, more silvery, than nickel, which latter has a peculiar tint, inclining to brownish white. About the year 1870 I plated one side of my riding bridle bit and one stirrup with cobalt, and the other side of the bit and other stirrup with nickel. The cobalt plating was distinctly handsomer, but the nickel lasted longer."

The Carbon Bottle Nitric Acid Couple of M. Faure.—The very interesting fact that nitric acid is utilised to a threefold extent in this battery, as compared to the ordinary Bunsen or Grove cell, has not, so far as we are aware, been hitherto noticed. In the last mentioned batteries, nitric anhydride (N_2O_5) is no doubt first decomposed into nitric oxide, yielding three atoms of oxygen; but the nitric oxide (N_2O_2), being evolved in contact with nitric acid, decomposes the latter, abstracting from it two atoms of oxygen, and thus becoming nitric peroxide (N_2O_4). Only one-fifth of the oxygen in nitric acid is thus utilised; but in the carbon-bottle battery the nitric acid which filters through the carbon is evolved in contact with the dilute sulphuric acid which surrounds the positive element, and becomes converted into nitric peroxide only when it reaches the air. The colourless gas may, in fact, be observed in its passage through the fluid, and may be seen to become reddened as it issues into the atmosphere. On the other hand, it should be observed that the economy in nitric acid resulting from the use of this form of cell would not be *two-thirds*, as might *primâ facie* seem to be the case. It is clearly indicated by theory that the electromotive force of a nitric acid cell must be somewhat higher when nitric peroxide is evolved from the cathode than when the gas evolved has a higher affinity for oxygen. Thus, although the economy of nitric acid *in each cell* would be exactly 66·6 per cent., the number of cells of the improved construction required to produce a given effect would, other things being equal, be somewhat greater than the number of Bunsen cells requisite to do the same work in the same time. Nevertheless, the economy of nitric acid effected by the use of Faure's battery is, probably, over 50 per cent.

On the Excitation of Electricity by Pressure and Friction.—1. It is well known that many crystalline bodies can be powerfully electrified by pressure. This, however, takes place in each case only under a perfectly definite condition. Calc-spar becomes electric only when pressed against another substance, never when pressed against another piece of calc-spar. Three pieces of calc-spar were laid one upon another; a pressure was then exerted upon the uppermost, which would have made each of the pieces singly distinctly electric: the central piece proved to be quite devoid of excitation; only the two outer ones possessed the usual quantity of electricity. If two calc-spars were pressed against one another, the surfaces which were in contact with the foreign bodies by which the pressure was exerted exhibited electricity distinctly; the two inner surfaces, where calc-spar had been in contact with calc-spar, were without excitation. I have not yet succeeded in carrying out the same experiment with other bodies. 2. According to previous observations, a definite substance, on undergoing friction against another, acquires always a certain invariable electrical excitation independent of the collateral circumstances, and accordingly the nature of the electricity excited is constantly the same. To test the correctness of this position, the following experiments were instituted, in which the collateral circumstances were varied as much as possible. *a.* With a violin-bow I stroked plates of zinc, copper, brass, and four different glasses, so that they vibrated transversally; they became only *negatively* electrified. If the same bow was drawn backwards and forwards lengthwise along the same part of the plate without producing a tone, it became only *positively* electric. *b.* Copper plates of 4 and 7 centims. diameter were whipped with white silk in various ways. If the stroke was delivered nearly perpendicular to the plate, the latter became strongly *positive;* if it was more nearly grazing, the plate became just as strongly *negative.* Whether the plate was fresh cleaned with hydrochloric acid, or by longer exposure to the air had become tarnished, made no difference, nor yet the size of the plate. Further, by *lightly* rubbing its entire rim (best with a silk or woollen cloth in the form of cone-cover), the plate is always rendered *negative;* by *hard* rubbing with the same silk on the same place, always *positive.* Coarse woollen cloth appeared to excite less powerfully. Zinc gave the same result. *c.* With brass the collateral circumstances appeared to have an influence. A square plate intended for the production of Chladni's sound-figures behaved exactly like the copper plate. The shallow brass scale of a table-balance, however, gave both electricities only when struck with silk, and when its surface was well cleaned. Lastly, an old pound-weight could not be excited in different ways with silk; this could only be accomplished with a violin-bow, according as the bow was applied to its thick main part, or to its thin neck. *d.* A small scale-pan of fine silver gave both electricities only with silk, with wool it only became negatively electric. *e.* A hard-gum plate always became *negative* when *slowly* stroked with a tightly folded linen cloth—when stroked *quickly*, in otherwise like circumstances, *positive.* The surface of the hand produced the same effect as linen; only for the positive excitation the stroking had to be very rapid. *f.* White silk always makes the principal-cleavage-surface of gypsum *positive*, but the second, which exhibits a vitreous lustre, *negative;* while it makes no difference whether the surfaces of this second cleavage are already present on the piece of gypsum, or are artifically produced by roughly scraping a surface of the principal one. Many other substances give opposite electric excitation on friction, according to the circumstances—for instance, mica struck with silk, hard gum rubbed with copper, hard gum whipped with silk, glass struck with silk; I have not, however, succeeded in discovering positive rules for this. The few experiments cited from above (from *a* to *f*) even show the impossibility of constructing a series of intensities for frictional electricity. If two bodies are rubbed against one another, the electricity excited in each of them may change into the opposite as the pressure, the velocity, or the direction of the rubbing motion, &c., varies. —H. Fritsch in *Wiedemann's Annalen.*

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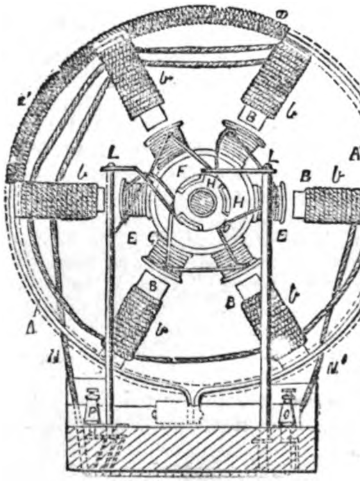
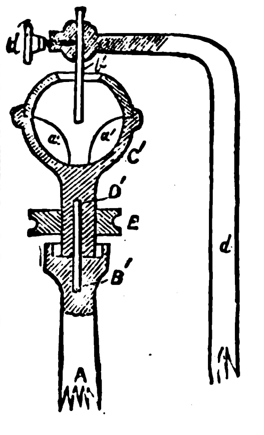
THE WESTON DYNAMO-ELECTRIC MACHINE.

By Paget Higgs, Assoc. Inst. C.E.

Dynamo-electric machines appear recently, with one or two exceptions, to have been considered as sources of the intense currents needed for the electric light. In the excitement and *éclat* of this novel system of illumination, a no less valuable application of these machines has been neglected. Electro-metallurgical pursuits were for long confined to the laboratory, or to those operations of gilding and plating requiring for commercial purposes only small expenditure of power. The introduction of the Wilde machine into the practice of the electrotype opened up an almost new branch of business, which, since the perfection of smaller magneto-electric machines absorbing less motive power, has developed into a distinct business involving considerable capital and giving employment to many. Electrotyping or electro-coppering is at the present day a valuable aid to many arts, not least of all to that of the printer; whilst electro-nickeling has, especially in the United States, brought into use many small artistic comforts that could not otherwise be produced at a cost within the reach of the general public. Indeed, it is scarcely doubtful that the more important and immediately valuable application of dynamo-electric machines is not to the end of obtaining the electric light, but to that of electro-deposition.

The Weston machine about to be described has obtained an important footing in the United States and in this country in many large electrotyping and plating establishments. It is proposed in this article, not to describe the applications of this machine, but to give the chief points in its construction somewhat in detail. The machine is one of that class in which the power from an engine or other motor is utilised and transformed into electricity, and it embodies the discovery, made by Wheatstone, of the principle of mutual accumulation; that is, the current generated by the revolving armatures is used to excite a stationary magnet, the latter being in circuit with the current from the armature. The machine consists of an iron drum or

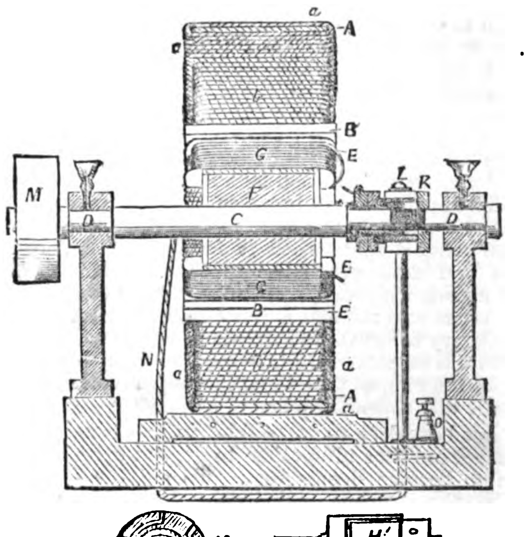


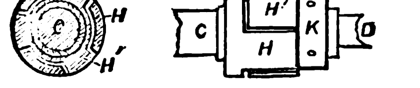


cylinder A, Figs. 1 and 3, supported by a wooden or iron base, the size of the cylindrical drum depending upon the size of the machine. From the interior of this ring a number of radially projecting magnets B are arranged, all pointing towards a common centre. These magnets are broad transversely and short radially. These magnets are wound with wire or ribbons *b* as well as the drum A, as at *a*. In the central space left between the inward ends of the magnets B is a shaft C, carried by suitable bearings D, and having upon that portion of it within the drum a series of armatures E. These armatures are all connected to an iron hub or centre F, and are of iron, wound with copper wire or ribbons as at G. The projecting ends of the armatures, when the shaft is revolved, pass closely, but without touching the ends of the magnets B, and currents of electricity are induced in the wires surrounding the armatures. These currents are constantly changing in each armature from positive to negative, and a commutator has to be used to bring them to one direction in the electric circuit.

Where a number of revolving armatures have been employed the commutators have generally been constructed with the requisite number of separate insulated strips, and with an equivalent number of springs or brushes, half of which number should be in connection with the armatures carrying positive or negative electricity, as the case may be, at the same moment. These numerous springs or brushes are always a cause of loss, for the connection made is not always perfect, and the metal is soon destroyed by the action of the current, or worn away, necessitating frequent adjustment and renewal. In the Weston commutator all the strips which convey currents of like kind are united in the commutator itself, and, therefore, it is only necessary to use the springs or brushes to collect the currents from all the armatures, no matter how many magnets or armatures may be employed. The commutator is made in two parts, H and H′, Figs. 1 and 5. One part, H, is slipped upon the shaft C, but is perfectly insulated from it, and from the other part, H′, both parts revolving with the shaft on which they are mounted. An adjustable clamping ring and nut K keep the two parts of the apparatus together. The number of projecting pieces which enter into spaces formed in the other half, but which do not touch or make metallic connection between the halves H and H′ correspond with the number of rotating magnets forming the armature. Only two springs or brushes are required, shown at L L′, Figs. 1 and 3. One is always in connection with one of the projecting pieces of the one half, while the other is always in connection with the other half of the commutator, one spring always carrying the positive currents and the other the negative currents.

The machine operates as follows:—The belt from the engine being put upon the pulley M, the armatures are put in rapid revolution, and a current of electricity is produced, which, flowing through first one half of the commutator, and then the other half, passes through the connecting wires N N′ to the coils *b* and *a*. This current, small at first, rapidly increases, and, exciting the magnets B, produces the maximum effect. From the coils *b* and *a*, the current is carried to the screw-terminal O, and thence to any desired circuit, returning to the terminal P, the spring L, and coils G. One half of the armature coils are connected with the part H of the commutator, and the remainder with H′, half of the separately wound armatures being positive, and the other half negatively excited alternately.





Thus far is the description of the machine complete. But in the application of dynamo-electric machines to the deposition of metals in a series of electrolytic cells, secondary actions occur, the effects of which are often of serious consequence. To avoid this is the object of a special appliance. If the two wires leading from the electrodes, immersed in a solution which has been undergoing electrolysis for a short time, be placed in connection with a galvanometer, a current will be indicated, but the direction will be the reverse of the electrolysing current. This current results from what is generally known as polarisation of the electrodes. Suppose that a dynamo-electric machine be connected to the electrodes of a deposition cell, and the machine is started, the solution will undergo electrolysis and the electrodes will become polarised; if the machine be stopped, it is evident that the current resulting from the polarisation will flow through the armatures and electromagnets, and being in the opposite direction to the original current, will reverse the polarity of the electromagnets, and when the machine is again started its current will flow in the opposite direction. In using such machines for practical plating, it is found that the polarity of the magnets is changed before the machine stops, the reverse current from the vats overcoming the feeble current produced by the machine at the slower speed. So that, if the polarity of the magnets change by reason of the machine being stopped, or run too slow, when the machine is again started, the current being reversed, the metal that has been previously deposited upon the articles in the

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vat will be dissolved, and the articles themselves, if metallic, attacked. The result may further be that the whole of the solution is spoilt, and much labour incurred in its chemical reduction and the purification of its valuable constituents. To overcome this difficulty various electromagnetic arrangements have been proposed by several inventors, in which, when the current ceases, the attractive force of an electro-magnet interposed in the circuit also ceases, and its armature is withdrawn by a counteracting spring, the withdrawal of the armature breaking the circuit. But it is obvious that, unless the electromagnet be polarised, that a reversed current may also cause attraction, and the device fail in the case of the slackening of speed without actual stoppage. The automatic break attached to the Weston machine is calculated to prevent such an accident, and can be adjusted to break and make circuit at any desired speed. A′, Fig. 2, represents a conducting pillar into which a steel pin, B′, is driven, upon this pin a cup C′, with stem D′, and pulley E′, is made to revolve by means of a belt leading from the shaft of the machine. This cup has ribs, or flanges *a*′, on the inner side of the lower half. At a little distance from the pillar A′ another conducting pillar G′ is placed and caused to project over and above the cup C′ carrying a wire rod *b*′ adjustable to any height by the thumbscrew *d*′. The rod *d*′ is amalgamated at the lower end, where it dips into the cup C′, in which is placed a small quantity of mercury. As long as the cup remains stationary the mercury will remain at the bottom, and the rod and the cup will be in metallic connection, but, if the cup be rotated at a certain speed, the mercury will rise up the sides of the cup, and the connection between the rod and the cup be broken. Supposing that the two wires from the machine are connected with the apparatus, one wire to each pillar and the machine started, the current will flow up the pillar A′ through the mercury, rod and pillar G′ to the other wire, and back again to the machine, thus completing the circuit. But, if the cup is caused to rotate, then it is obvious that, when the machine, and consequently the cup, have reached a certain speed, the connection will be broken, the circuit opened, and the current would flow through the depositing vats if these were also connected to the pillars. When the machine, and consequently the cup, fall to a certain speed, the current from the vats would flow through the mercury and soon be exhausted. By a slight modification this apparatus may be made to close the circuit between the vats and the machine when the machine reaches a certain speed, and break it again when it falls below that speed. This method is preferable with large machines, because these, when on closed circuit with small resistance, require considerable power to start them, and the belt is very liable to run off before the speed necessary to break the circuit is reached. In this case, a disc of metal is employed slightly smaller than the largest inside diameter of the cup, so that when the cup revolves and the mercury rises it will touch the disc.

But it has been deemed advisable, in the construction of the Weston machine, not altogether to depend upon the liability of soft iron to become depolarised. To aid the electro-magnets in retaining the required polarity they are faced with plates of hardened steel, which, having much greater coercive power, completely removes the liability to the reversal of polarity.

Some idea of the power of these machines may be gathered from an experiment made by the author, which verifies and is verified by measurements made in the United States by Mr. Keith and others. A machine, the cylinder of which was 16 inches in diameter and about 10 inches wide, was put in circuit with an electrolytic bath of which the anode and cathode were copper sheets of twenty-five square feet surface, placed two-and-a-half inches apart in a concentrated solution of sulphate of copper. With an indicated expenditure of work of 1 H.P. upon the driving belt, the current from the machine deposited an average of two pounds of copper per hour in reguline metallic condition, which is very nearly the theoretical rendering of such a machine. The value of other electrolytic work such a current could be made to accomplish can be ascertained from the following table :—

	c.c.m. Water Gases.	Units of Weight of :— Water.	Copper.	Silver.
Cubic cm. Water Gases }	—	0·5363	1·889	6·432
Units of Weight of :—				
Water	1·865	—	3·522	11·99
Copper	0·5294	0·2829	—	3·405
Silver	0·1555	0·0834	0·2937	—

So that, if 2lbs. of copper were deposited, it may be assumed that, under equivalent conditions, $2 \times 3{\cdot}405 = 6{\cdot}810$lbs. of silver would be thrown down. The equivalent conditions would, however, include electrodes of such a size as to give that density of current per unit of surface required for the reguline deposit of silver.

THE RESISTANCE OF THE ARC OF THE ELECTRIC LIGHT.*

By Professors W. E. Ayrton and John Perry, of the Imperial College of Engineering, Tokio, Japan.

Some time back Professor Perry and myself, desiring to know the resistance of the arc of the electric light for the purpose of theoretically determining the best arrangement of the battery, and not being acquainted with any source from which this information could be derived, proceeded to measure it in two destinct ways.

First :—A current from sixty Grove's cells joined in series was sent through a Dubosc's lamp in circuit with a small resistance composed of many yards of bare copper wire suspended in the air, and of sufficient thickness not to be heated by the passage of the strong current. The differences of potentials between the carbons and between the ends of the known resistance were then rapidly measured one after the other a number of times with a Thomson's quandrant electrometer, using the induction plate; the two differences of potential so measured being, of course, proportional to the resistances, since the same current traversed the whole circuit at any moment.

The result obtained was that the resistance of the electric arc varied considerably, never, however, exceeding twenty ohms, and having a mean value of about twelve ohms.

Second :—On a subsequent occasion we measured the resistance in another way. The current from eighty Grove's cells in series was sent through the two coils of a Latimer Clark's differential galvanometer to which we had attached a silk fibre suspension, using the method of centering described by Professor Perry and myself in your Journal, vol. vi., page 335, 1877. One of the coils of the differential galvanometer was in circuit with the electric light, and was shunted with an extremely small shunt of thick copper wire, the other coil being also shunted and in circuit with a high resistance. Almost all the current, therefore, passed through the electric light circuit, and balance was obtained by altering both the shunts and adjusting the resistance coils. Although the resistances of the shunts were rather too small to be easily measured with accuracy, still the resistance of the luminous arc was correctly determined by a method corresponding with that of "double weighing;" that is to say, by replacing it with a resistance coil, and altering this coil until balance was obtained with exactly the same adjustments of shunts, &c., as were employed when the electric light was in circuit.

The resistance of the light so determined showed that it never exceeded 29 ohms, and was equal to about 20 ohms when the light was best.

Recently, having occasion to use one hundred and twenty-two Grove's cells with an electric light in connection with the celebration of the official opening of the Imperial Telegraphs of Japan, and the participation of that administration, for the future, in the international system of working prescribed by the St. Petersburg Convention, I took the opportunity to again measure the resistance of the electric light, using the differential galvanometer method last described, and for carrying out which I have found the Latimer Clark's galvanometer with a fibre suspension very convenient. Experiments extending over an hour showed that the resistance had a maximum value of forty-eight ohms, and a mean value of about thirty ohms when the carbon points were a little less than three-quarters of an inch asunder and the light painfully bright.

In the first two determinations of the resistance the Grove's cells employed were of the ordinary English rectangular form with flat Wedgewood porous cells, the area of the platinum plate immersed being about thirteen square inches, and of the zinc plate about twenty-five square inches. In the third and last experiment 108 of the cells were of the same kind, and the remaining fourteen were very large round cells, the area of each platinum plate immersed being about the same as before, but that of each zinc plate immersed being larger; on the other hand, however, the distance between the platinum and zinc in each of these larger cells was greater, so that in all cases the resistance of each cell may be regarded as having been approximately the same, or about 0·2 ohms.

* From the new *Journal* of the Society of Telegraph Engineers.

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The results then obtained may be shortly stated thus:—

Number of Grove's cells in series.	Resistance of the battery.	Approximate mean resistance of the electric arc.
60	12 ohms	12 ohms
80	16 ,,	20 ,,
122	24·4 ,,	30 ,,

With the ordinary rectangular English Grove's cells, then, the resistance of the light appears to be about equal to that of the battery when sixty cells are employed, and to increase more rapidly than that of the battery as the number of cells is increased. If this law be found to be true for larger batteries, or even if the resistance of the electric light be only found to increase proportionately to that of the battery, still, contrary to what is stated in certain books, it will follow that the cells used for the production of the electric light should in every case all be joined in series and no part in parallel circuit, even when some hundreds are employed.

W. E. Ayrton.
John Perry.

The Imperial College of Engineering, Japan.
April, 1878.

EDISON'S ELECTRIC LIGHT.

The *New York Herald* of the 12th of October has the following on this subject:—

"The alarm among the English gas companies, and the panic in their stocks on account of Edison's last invention in electric lights, as narrated in yesterday's *Herald* cable despatches, are not without good cause. America's great inventor has, in truth, solved the problem which for years had puzzled the ablest electricians of the age. He has successfully divided the electric light, and has made it, for illuminating purposes, as far superior to gas as gas is to the tallow candle of the past. His marvellous invention gives a mild, soft, yet brilliant light, pleasing to the eye, clear, steady, and without blemish, and at a cost less than one-third of that required for gas. Those who have seen the invention pronounce it wonderful. Already a company has been formed, composed of a number of wealthy capitalists, and Mr. Edison's lawyers are engaged in completing the final arrangements for the legal transfer. Before long, therefore, the work of introduction, will begin. The patents for the United States have only just been granted, while those for the various countries of Europe have not yet been obtained. To-day the Professor's solicitors send by steamer the necessary documents to their London agents for procuring the British letters patent. The French and other patents will be applied for simultaneously with the English one. When word is cabled Mr. Edison that the patents have been granted he will throw his invention open to the public gaze; but until then he declines to make known its details, his recent controversy with Professor Hughes over the alleged stealing of the microphone having made him cautious. When the other great inventions of Mr. Edison were in progress, the laboratory was free to all visitors. The telephone was seen by hundreds long before letters patent were granted. The same was the case with the phonograph, the tasimeter, the megaphone, the quadruplex, and many other of his inventions. The case of the electric light is far different. Its place in the laboratory is one sacred to a favoured few. If the host of visitors who daily swarm the laboratory of the great inventor see it, they see it only in a detached form. The essence of the discovery is missing. Mr. Edison himself speaks but little of the subject, but he is almost constantly at work on it. Early morning sees him in the laboratory, and it is after midnight when he leaves. On Thursday last he worked continuously from sunrise until sunrise the following day, and ceased then only after the earnest importunities of his assistants. All his energies seem wrapped up in the new invention. His megaphone and phonograph lie idle, save for the work done on them by some of the Professor's numerous assistants. A *Herald* reporter learned yesterday the system proposed to be adopted after the patents are all granted. First, the Professor will light up all the houses in Menlo Park gratis, and from his laboratory watch the lights' progress from night to night. When all is in readiness for general introduction, central stations will probably be established throughout Yew York city, each station controlling a territory of, perhaps, a radius of half a mile. Wires will then be run in iron pipes underground, after the manner of gas pipes, connecting dwellings, stores, theatres, and other places to be lighted. The gas fixtures at present used, instead of being removed, will be utilised to encase the wire. In the place of the burner will be the invention, and meters will be used to register the quantity of electricity consumed. The form is not yet determined upon. The light is to be of the batwing, 15-candle power character. To kindle it a little spring is touched, and instantly the electricity does its work. The amount of light can be regulated in the same way as can that from gas. To turn off the light the spring is again touched, and instantly all is darkness. No matches being used, and there being no flame, all the dangers incidental to the use of gas are obviated. The light gives out no heat. It is simply a pure white light, made dim or bright at the fancy of the person using it. The writer last night saw the invention in operation in Mr. Edison's laboratory. The inventor was deep in experimental researches. What he called the apparatus consisted of a small metal stand placed on the table. Surrounding the light was a small glass globe. Near by was a gas jet burning low. The Professor looked up from his work to greet the reporter, and in reply to a request to view the invention, waved his hand towards the light, with the exclamation, 'There she is.' The illumination was such as would come from a brilliant gas jet surrounded with ground glass, only that the light was clearer and more brilliant. 'Now I will extinguish it and light the gas, and you can see the difference,' said Mr. Edison, and he touched the spring. Instantly all was darkness. Then he turned on the gas. The difference was quite perceptible. The light from the gas appeared in comparison tinted with yellow. In a moment, however, the eye had become accustomed to it, and the yellowish tint disappeared. Then the Professor turned on the electric light, giving the writer the opportunity of seeing both side by side. The electric light seemed much softer; a continuous view of it for three minutes did not pain the eye; whereas looking at the gas for the same length of time caused some little pain and confusion of sight. One of the noticeable features of the light, when fully turned on, was that all colours could be distinguished as readily as by sunlight. 'When do you expect to have the invention completed, Mr. Edison?' asked the reporter. 'The substance of it is all right now,' he answered, putting the apparatus away and turning on the gas. 'But there are the usual little details that must be attended to before it goes to the people. For instance, we have got to devise some arrangement for registering a sort of meter, and again there are several different forms that we are experimenting on now in order to select the best.' 'Are the lights to be all of the same degree of brilliancy?' asked the reporter. 'All the same.' 'Have you run across any serious difficulties in it as yet?' 'Well, no,' replied the inventor, 'and that's what worries me, for in the telephone I found about a thousand obstacles, and so in the quadruplex. I worked on both over two years before I overcame them.' Mr. Batchelor, the professor's assistant, who here joined in the conversation, said, 'Many a time Mr. Edison sat down almost on the point of giving up the telephone as a lost job, but at the last moment he would see light.' 'Of all things that we have discovered, this is about the simplest,' continued Mr. Edison, 'and the public will say so when it is explained. We have got it pretty well advanced now, but there are some few improvements I have in my mind. You see, it has got to be so fixed that it cannot get out of order. Suppose where one light only is employed it got out of order once a year; where two were used it would get out of order twice a year, and where a thousand were used you can see there would be much trouble in looking after them. Therefore, when the light leaves the laboratory, I want it to be in such a shape that it cannot get out of order at all, except, of course, by some accident.' Leaving Mr. Edison to continue his work, the reporter accepted the invitation of Mr. Griffin, his private secretary, to view the generating machine. 'Mr. Edison has just purchased a new one,' he said 'which gives much power, and in a few days we shall have a 50-horse power engine to work it, as we do not get power enough with the present one. As regards the generators,' continued Mr. Griffin, 'Mr. Edison has as yet given but little attention to them. The cost can, by an improved generator, be reduced to a much smaller figure.' None of the New York papers have any leaders or comments on the discoveries, or on the gas scare in London, although telegrams from London respecting the latter event appear in their columns."

Western Union Telegraph Company.—At a meeting of the stockholders of this Company, at New York, on the 9th inst., the annual report was presented, showing the capital stock to be $41,073,410, and the net profits for twelve years, from July, 1866, to June 1878, to be $35,933,823. In 1866 the Company possessed 75,686 miles of wire and 2,250 offices; in the present year it has 206,202 miles of wire and 8,014 offices. The number of messages transmitted in 1868 was 6,404,595, and in 1878, 23,918,894; whilst in the former year the average cost of transmitting a message was 63·4 cents, and in the latter year 25 cents.

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THE ELECTRICIAN.

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THE NATURE OF EDISON'S INVENTION.

Many are the surmises as to the principle on which Mr. T. A. Edison founds his electric lamp, and but few of these appear to properly appreciate the real difficulties of the problem. Mr. Edison has pointed out these difficulties very clearly, and has sufficiently indicated the manner in which he overcomes them. In the first instance, carbon has been universally adopted as the wick, so to say, of the lamp, under the form of rods or slabs; but the carbon is consumed more or less rapidly and has to be continually renewed. Indeed, an electric lamp consuming carbon would be as troublesome to manage as the oil lamp of former days. Further, the consumption of the carbon points causes considerable variation in the resistance offered by the circuit to the electric current, and such variation in the case of most dynamo-electric machines that work on the accumulative principle is multiplied in the machine itself, the result being an unsteady or flickering light. This variation in resistance is also the chief cause of failure of the attempts to subdivide the electric light, because it becomes increased in a far greater ratio than the number of lamps employed. The carbons, too, unless of very superior quality, are apt to split and fly off in molten incandescent particles. Such defects would in themselves preclude the use of carbon points. Mr. Edison surmounts all these difficulties by avoiding them. He embeds the ends of the conducting wires into a broad, flat cake of some substance that is unattacked by the atmosphere when raised to incandescence by the passage of the current across it. What this substance is Mr. Edison has not yet told us, but there are several known to electricians that would answer the purpose. This very simple arrangement is enclosed in a small ground glass globe, and the light evolved is said to be soft and pleasant to the eye. As there is no consumption, there is no variation in the resistance of the circuit; and there may, consequently, be as many separate lamps in work at one time as the current is powerful enough to ignite or supply. That the arrangement could not well be simpler is apparent. These lights can be supplied from wires brought along a moderate-sized gas-pipe, electricity, in fact, taking the place of gas. Such an arrangement admits, also, of another advantage, that dynamo-electric machines giving currents of single direction can be employed; and this description of machine is more economical in work than machines giving currents in alternate directions, since no work is absorbed in magnetising and demagnetising the iron cores, and in the heat consequent thereupon. Now that inventors know in which direction it is best to work, we may doubtless soon hear of other lamps competing with Mr. Edison's.

THE TECHNICAL TRAINING OF TELEGRAPH ENGINEERS.

In our issue of the 5th instant we referred to the desirability —nay, the absolute necessity—of an organized system of instruction in Telegraphy being started in Great Britain, and we suggested that the Society of Telegraph Engineers, which has prospered so well in all that it has taken in hand that its numbers, in less than eight years have increased tenfold, should now undertake the higher technical education of students of electricity.

Telegraphy has long ceased to be that rule of thumb art which could be the only excuse for this subject not forming, like other branches of engineering, one of the courses at our British Universities. Like other branches of engineering, we say—but does engineering form one of the courses of our Universities? Are English colleges, like continental ones, well equipped with engineering laboratories presided over by a large and highly trained staff of professors and assistants in the various branches of engineering? We are afraid we must confess that as a nation we are but just commencing to realize that technical education is only second to elementary instruction, and we are now beginning to lay foundation stones of laboratories which long ago ought not only to have been constructed, but ought to have for years sent forth a constant stream of students trained in technology.

In that soul-stirring address of Professor Morley, at University College, on the 2nd inst., we were charmed to hear that it was the original scheme of that college to teach engineering, and we see under that head in the syllabus of instruction for this year "Telegraphic Engineering," the course extending, as is very proper, over four years; but, on turning to the list of professors, we find only one to teach all the three distinct subjects—civil engineering, mechanical engineering, and telegraph engineering. It is clear, therefore, that, unless he has several highly trained engineers as assistants whose names do not appear in the list of the staff of the college, or unless the total number of students who have selected one or other of these three professions be extremely small, then some two of these subjects can necessarily receive but little attention, even from so highly-gifted a man as Professor Kennedy. It is true, of course, that the elementary education of telegraph engineers, like that of other engineers, can be obtained in the general mathematical, natural philosophy, chemistry, and drawing classes of a college, but their technical education, the training which is to make them engineers, not merely engineering students, requires the almost undivided attention of at least one professor. Again, although the four years' course for telegraph engineers at University College comprises the subjects geometry, physics, chemistry, geometrical and engineering drawing, the theory

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of machines, physical and engineering laboratory, we see no provision for these students receiving any special lectures on telegraph engineering.

We presume, of course, that, as there is no separate telegraphic laboratory, the physical laboratory is fitted up not only with all the standard signalling, receiving and testing instruments, but with such apparatus as "inductive resistances" for experiments on retardation in submarine cables, &c., &c.; but we hardly see how one single Professor of Natural Philosophy, who has numerous lectures to give to the general students, can possibly find time to superintend experiments of such delicacy, especially now that his assistant, in consequence of the illness of the Professor of Applied Mathematics and Mechanics, is holding also some classes on these subjects. In fact, we think that University College must admit, although their desire is "to lead and not be among the followers," that, as regards the special training of telegraph engineers, this leading is, for the present, merely confined to their announcing that some of the college courses may be judiciously attended by students who purpose devoting themselves subsequently to the study of telegraph engineering.

We presume, of course, that it is merely the absence of funds that causes the incompleteness in the proposed education of telegraph engineers at University College, and we have no doubt that the Council are fully alive to the necessity for improving it. Still, we think it advisable to point out, when considering the requirements of a student of telegraphy, how little he can hope to obtain at even that educational institution, which is, perhaps, the most advanced in this country.

The only college at which telegraphy is systematically taught in the English language—in fact, the only English-speaking technical university with which we are acquainted—is the Imperial College of Engineering in Japan. Here, as long as six years ago, students of telegraphy were not tacked on to other college courses, but were recognised as a distinct body, and trained by a professor who was a professional telegraph engineer. Here we have separate museums devoted not only to civil and mechanical engineering models, but one to telegraphic apparatus, and of which the short preliminary printed catalogue occupied some twenty pages. Here, also, we have a laboratory, with a workshop attached, a laboratory, be it remembered, distinct from the physical and engineering laboratories, devoted solely to students of telegraphy, and in which we presume much good work must be performed, judging from the numerous results of original research that have issued from it during the last few years, among which we may mention the measurements of the different specific inductive capacities of gases, contrary to the views of Faraday; a large series of new experiments of vital importance on the contact theory of voltaic action; some valuable experimental contributions to Professor Clerk Maxwell's electromagnetic theory of light, and the recent re-determination in a new way of that important electrical constant "V," the number of electrostatic units of quantity in an electromagnetic one, not to mention a large number of purely telegraphic communications that have from time to time appeared in the various telegraphic periodicals of the day. From the syllabus we see that the students of telegraphy at this college receive, in addition to the ordinary lectures and practical work in mathematics, natural philosophy, chemistry, and drawing, given by the various professors in these subjects, about one hundred on the higher parts of electricity and magnetism, as applied to telegraphy, thirty on the history of the telegraph in which the various improvements that have taken place are traced step by step, and the more important abandoned designs examined to ascertain the reason of the failure, twenty lectures on the construction of a line of telegraph, thirty on the working, twenty on submarine cables, and a few on torpedos and military telegraphy.

Now, it is clear that some such scheme as that is what Great Britain now requires, a scheme which, while it gives a complete training in telegraphy, is eminently suited to foster originality and invention.

One of the greatest aids to teaching and research is a good library for reference. But already the Society of Telegraph Engineers possesses, through the generosity of the late Sir Francis Ronalds, probably the finest electrical library in the world. It now becomes their duty, as we know it is their wish, to render it of the greatest value to its members and to the world. Now, we know of no better way, and certainly none more in keeping with the characteristic genius for experimenting of its first owner, than their adding to it a Physical Research Laboratory.

Mr. Preece, in his recent report on the telegraphs in the United States, speaks with unbounded admiration of the telegraphic laboratory there which is placed at the disposal of Mr. Edison. To maintain such a laboratory with its staff of assistants and mechanicians costs money. Of course, it does; so also does sending a young boy daily to school. But surely, at the present day, no one in his senses is so bad a political economist as to suggest non-education of children. But just as the early training of the boy makes the man, so does the technical education that electrical students can receive in a telegraph laboratory produce telegraph engineers, and, in addition, the results of original research, which are the natural outcome of such a laboratory when properly conducted, play an important part in the advancement of science.

In what has preceded we have been referring to the electrical training of telegraph engineers; some part of their knowledge of surveying and of construction, mainly, of course, the theoretical portions, can be obtained from lectures and from experiments on strength of materials, &c., performed in the laboratory; but the actual practice—that practice which alone makes perfection—must necessarily be obtained in the field. We would, therefore, recommend some such scheme as that followed at the Imperial College of Engineering at Japan, where, with the exception of the first year's course, half the year is spent at lectures and in the laboratory, and the other half in surveying and constructing actual telegraph lines.

ON THE RESISTANCE OF TELEGRAPHIC ELECTRO-MAGNETS.*

BY OLIVER HEAVISIDE.

[CONCLUDED FROM PAGE 245.]

From (10) we may find the coefficients of induction of suspended wires, the circuit being completed through the earth. Let M be the coefficient of mutual induction, and L_1 L_2 the coefficients of self-induction of two wires of radii a_1 a_2, heights above ground h_1 h_2, horizontal distance apart d, and specific magnetic capacities μ_1 μ_2; then

$$\left.\begin{aligned} \frac{L_1}{l} &= \frac{\mu_2}{2} + 2 \log \frac{2\,h_1}{a_1}, \\ \frac{L_2}{l} &= \frac{\mu_2}{2} + 2 \log \frac{2\,h_2}{a_2}, \\ \frac{M}{l} &= \log \frac{d^2 + (h_1 + h_2)^2}{d^2 + (h_1 + h_2)^2}, \end{aligned}\right\} \quad . \; . \; . \quad (12)$$

where μ_0 is made equal to unity. As a practical case, let

* From the *Philosophical Magazine*.

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$h_1 = h_2 = 3$ metres, $a_1 = a_2 = \cdot 002$ metre, $\mu_1 = \mu_2 = 1 + 4\pi\kappa = 315$, if $\kappa = 25$, and $d = \cdot 5$ metre. Then $L_1 = L_2 = 173$, $M = 5$ approximately. Also, if the resistance is 13 ohms per mile, the resistance per centimetre is 80778 c. g. s. Therefore

$$\frac{L_1}{R_1} = \frac{173}{80778} = \cdot 00214 \text{ second.} \quad . \quad . \quad . \quad (13)$$

6. This time interval being in general very small compared with $\frac{L}{R}$ for the electromagnet, we may neglect it; and then (5) becomes

$$\frac{R}{R_1} = \frac{1}{\sqrt{1 + m^2 \frac{L^2}{R^2}}},$$

or $R_1 = L\,m$ approximately. The resistance of the electromagnet for high speeds varies inversely as the speed to obtain the maximum strength of signals. Using the value of $\frac{L}{R}$ given in (9), we have

$$\frac{R}{R_1} = \frac{T}{14\cdot 64 \frac{x - y}{x + y} \cdot z^2}$$

where $T = \frac{2\pi}{m}$. At 100 words per minute Morse code, T = about $\frac{1}{40}$ second. Therefore, at this speed, $\frac{R_1}{R} = 585\cdot 6 \frac{x - y}{x + y} z^2$.

Suppose $x = 2$, $y = z = 1$ centimetre; then $\frac{R_1}{R} = 195\cdot 2$; or the resistance of the electromagnet is 1-195th part of the external resistance to obtain the maximum magnetising force—a very low result. If $\frac{L_1}{R_1}$ is taken into account, this becomes 1-174th.

7. Having made the magnetising force a maximum for a given speed and size of electromagnet, by varying the thickness of the wire, we may next find the ratio between the outer and inner radius of the coil to make the attractive force between the core and a soft-iron armature a maximum. We have

$$\Gamma = \frac{E}{\sqrt{(R + R_1)^2 + L^2 m^2}}$$

(neglecting L_1), where

$$L = \tfrac{2}{3}\pi^2 l n^4 (x - y)^2 (x^2 + 2xy + 3y^2 + 24\pi\kappa z^2),$$
$$R = \pi \rho l n^4 (x^2 - y^2).$$

Also $F = \Gamma G$, where F is the magnetising force, and

$$G = 4\pi n^2 (x - y).$$

To make F a maximum, n being variable, we found

$$R^2 + L^2 m^2 = R_1^2.$$

Therefore

$$F = \frac{E\,G}{R_1 \sqrt{2\left(1 + \frac{R}{R_1}\right)}}.$$

Substituting

$$4\sqrt{\frac{\pi (x - y) R}{\rho l (x + y)}} \text{ for G,}$$

we have

$$F^2 = \frac{\frac{8\pi (x - y) E^2}{\rho l (x + y)}}{R_1 \left(1 + \frac{R_1}{R}\right)}.$$

Now

$$\frac{R_1}{R} = \sqrt{1 + \frac{L^2 m^2}{R^2}} = \frac{L\,m}{R} \text{ approximately,}$$
$$= \frac{2m\pi}{3\rho} \frac{x - y}{x + y} (x^2 + 2xy + 3y^2 + 24\pi\kappa z^2).$$

Therefore

$$F^2 = \frac{\frac{12E^2}{R_1}}{lm\,(x^2 + 2xy + 3y^2 + 24\pi\kappa z^2) + \frac{3\rho l}{2\pi}\frac{x + y}{x - y}}.$$

Now, the magnetisation of the core is proportional to the magnetising force; and the attractive force between the core and a soft-iron armature placed close to it is proportional to the square of the magnetisation and to the cross section of the core. Therefore, if A is the attractive force,

$$A \propto \frac{z^2}{lm\,(x^2 + 2xy + 3y^2 + 24\pi\kappa z^2) + \frac{3\rho l}{2\pi}\frac{x + y}{x - y}}. \quad (14)$$

This increases with z; therefore, let $z = y$, the inner radius of the coil; let x be constant and y variable. Then A is a maximum when $\frac{x^2}{y^2} + \frac{2x}{y} + \frac{3\rho}{2\pi y^2 m}\frac{x + y}{x - y}$ is a minimum, and that is when

$$\frac{2m\pi}{3\rho} x^2 = \frac{\frac{y}{x} - \left(1 - \frac{y^2}{x^2}\right)}{\left(1 - \frac{y}{x}\right)\left(1 - \frac{y^2}{x^2}\right)}.$$

The least value of $\frac{y}{x}$ is $\frac{y}{x} = \frac{\sqrt{5} - 1}{2} = \cdot 618$. Using the former value of ρ, viz. $1700 \times \frac{4}{\pi}$, also $m = 80\pi$ and $x = 2$ centimetres, then $\frac{y}{x} = \cdot 7$ nearly. $\frac{y}{x}$ increases very slowly as x and m increase.

In this determination of $\frac{y}{x}$ the outer radius has been supposed to be constant and the inner variable, and with it the iron core. If, on the other hand, the inner radius is fixed and the outer variable, a different ratio is obtained, viz.:—

$$\frac{2m\pi}{3\rho} x^2 = \frac{\frac{y}{x}}{\left(1 - \frac{y}{x}\right)\left(1 - \frac{y^2}{x^2}\right)},$$

which gives lower values to $\frac{y}{x}$ than before.

It also appears from (14) that the attractive force varies inversely as the length of the coil. Though the formulæ are only true for long coils, yet it points in the direction of short, flat coils; for the attractive force is also increased by increasing the transverse dimensions of the coil.

8. In paragraph 5 we found $L_1 = 173$ and $M = 5$ approximately for iron wires of a certain size, distance apart, and height above ground. The ratio $\frac{L_1}{M} = 34$ expresses the ratio of the strength of the sinal wave currents in the wire containing the electromotive force E sin. mt to the corresponding induced currents in the parallel wire, or, rather, the minimum value of that ratio for rapid reversals. For, if R_1, L_1 belong to the primary circuit, R_2 L_2 to the secondary, then

$$\Gamma_1 = \frac{E\sqrt{R_2^2 + L_2^2 m^2}}{\sqrt{\{R_1 R_2 - m^2 (L_1 L_2 - M^2)\}^2 + m^2 (R_1 L_2 + R_2 L_1)^2}},$$

and

$$\frac{\Gamma_2}{\Gamma_1} = \frac{M\,m}{\sqrt{R_2^2 + L_2^2 m^2}}.$$

As m approximates to $\frac{\Gamma_2}{\Gamma_1} = \frac{M}{L_2}$, equal to about $\frac{1}{34}$ if there are no electromagnets in the secondary circuit, otherwise much less. It is here assumed that $\kappa = 25$ for the iron wire.

THE RESISTANCE OF GALVANOMETER COILS.*

By Professors W. E. Ayrton and John Perry, of the Imperial College of Engineering, Tokio, Japan.

In connection with the winding of galvanometer coils, the three following questions have been solved :—

1. What is the best resistance to give to a galvanometer coil of fixed shape and size when *one* guage of wire *only* is employed in winding it, and when the thickness of the insulating coating is constant?

Answer. Make

$$\frac{\text{the resistance of the } coils}{\text{the } external \text{ resistance}} = \frac{\text{the radius of the } bare \text{ wire}}{\text{the radius of the } covered \text{ wire}}.$$

(See C. Maxwell's "Electricity," page 321), which equation, of course, reduces itself to making the resistance of the galvanometer equal to the external resistance when the covered wire is considered as having the same diameter as the bare wire.

2. What is the best shape to give to a galvanometer coil?

Answer. Make the outline of a section through the axis of the instrument satisfy the polar equation $r^2 = x^2 \sin.\theta$ where r is the radius vector, θ the variable angle, and x the height of the coil measuring from the axis. (See C. Maxwell's "Electricity," page 322.)

3. If wire of *various* thicknesses be wound on the galvanometer coil, but so that the surface bounding the wire of any one thickness satisfies the preceding polar equation, then what gauges of wire should be employed?

Answer. If y is the radius of the bare wire in a layer whose maximum distance from the centre of the coil is x, and if Y^2, a function of y, is the average space allotted to the wires in this layer, including waste space between them, then the following

* From the new *Journal* of the Society of Telegraph Engineers.

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differential equation must be fulfilled to obtain maximum sensibility:—

$$\frac{x^2}{y^2}\left(1+\frac{Y}{y}\frac{d\,y}{d\,Y}\right) = \text{a constant.}$$

(See Maxwell's "Electricity," page 342.)

Now, if Y is proportional to y, then the preceding differential equation leads to the result that both Y and y must be proportional to x, or the radius of the wire varies as the linear dimensions of the coil.

But, under these circumstances, what should be the resistance of the galvanometer? Should condition (1) be satisfied—that is, should the resistance of the galvanometer bear to the external resistance the ratio that the radius of the bare wire bears to that of the covered—or, if not, what is the condition that gives maximum sensibility to the galvanometer? As we do not find in books the answer to this question, we have thought it not unworthy of thé nôtice of the Society, although the method by which it is obtained is comparatively simple.

It may easily be shown that, if G is the resultant magnetic force at the centre of a galvanometer coil due to unit current, and if R is the resistance of the coil, and ρ the specific resistance of the metal employed in making the wire, then

$$d\,G = N\frac{d\,x}{Y^2},$$

and

$$d\,R = N\frac{\rho}{\pi}\frac{x^2\,d\,x}{Y^2\,y^2},$$

where N is a numerical quantity. Consequently, if y and Y are both proportional to x, the condition assumed above, we have, by integrating, if

$$y = a\,x,$$

and

$$Y = \beta\,y,$$

$$G = N\frac{1}{a^2\,\beta^2}\left(\frac{1}{a}-\frac{1}{x}\right),$$

$$R = N\frac{\rho}{\pi}\frac{1}{a^4\,\beta^2}\left(\frac{1}{a}-\frac{1}{x}\right)$$

where a is the radius of the cylindrical space left at the centre of the coil for the needle and mirror, and consequently not filled with wire.

Now, if E is the electromotive force of the battery, and r the external resistance in circuit, the total magnetic force at the centre of the coil is

$$\frac{N}{a^2\,\beta^2}\left(\frac{1}{a}-\frac{1}{x}\right)\times\frac{E}{r+N\frac{\rho}{\pi}\frac{1}{a^4\,\beta^2}\left(\frac{1}{a}-\frac{1}{x}\right)}.$$

Then a, which determines the relationship between y and x, is our variable which has to be evaluated, while β is, by the conditions of the problem, a constant.

For $\frac{N}{\beta^2}\left(\frac{1}{a}-\frac{1}{x}\right)$ write M; then the expression given above becomes

$$\frac{E}{\frac{r}{M}a^2+\frac{\rho}{\pi\,a^2}},$$

which, by the well-known laws of the differential calculus, is a maximum, when $\frac{r}{M}a^2 = \frac{\rho}{\pi\,a^2}$, or *when the resistance of the galvanometer is equal to the external resistance.*

Curiously enough, then, we arrive at the same condition for maximum sensibility, both when the radius of the bare wire is equal to that of the covered—that is, when the thickness of the covering is altogether neglected—and when the area allotted to each wire bears to the area occupied by the metal itself a constant ratio in every layer.

W. E. Ayrton.
John Perry.

The Imperial College of Engineering, Japan,
April, 1878.

CORRESPONDENCE.

THE ELECTRIC LIGHT.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I am certain—judging by the moderate and impartial tone of articles which have appeared in your useful journal—that you do not intend unfairly to lay any mis-statements to my charge; yet, in referring to my pamphlet, "Remarks on the Electric Light," you inadvertently do me an injustice. The paragraph you quote is expressly stated by me to be part of an address I delivered on the 18th July, 1877, and my authority for the assertion you impugn is the valuable work, "Eclairage à l'Electricité, Renseignements Pratiques, par Hippolyte Fontaine" (Baudry, Paris, 1877), in which, at the top of page 236, you will find these words:—"*Les bougies peuvent, nous assure-t-on, durer trois quarts d'heure. Au Louvre on les remplace toutes les demi-heures.*"

I think you must admit that, with this before me, my remarks at that time were fully justified.

My pamphlet is intended to show, to a limited circle of readers, what progress (or, may I be permitted to say, without offence, what little practical progress?) has been made since then. At page 9 you will find I freely admit that one light may *now* be maintained for several hours without the interruption attending every replacement of the candles.

With regard to the use of machines and engines for a few hours daily, I can but speak of things as I find them. When electricians have proved by practical demonstration in public, and not merely by laboratory experiments, that machines and engines may be dispensed with for household lighting by electricity, then I and the rest of the world will necessarily be convinced; but, meanwhile, I must be allowed to limit my faith to the evidence before me.

I will only add that the difficulties in the way of gas companies willing to take up the electric light are considerable. For which system are they to seek a license? That of Jablockhoff, Rapieff, Wielde, Siemens, Lontin, Edison, or any other of the host of patentees, each of whom imagines his own particular "invention" to be the best? I fear that these estimable but too sanguine men of science will have to fight many battles amongst themselves in and out of Chancery before the survivor, if any, can show a clear title to realise the value of his arduous labours.

H. M. Backler.

11, Austin Friars, London, E.C.,
19th October, 1878.

ANSWERS TO CORRESPONDENTS.

Thos. Metcalfe.—The *intensity* of a current—a term derived from the French *intensité*—signifies simply *the current, i.e.,* the quantity of electricity passing in a given time. The *electromotive force* of a source is that property which enables it to overcome resistance to the propagation of electrical effect. The *external resistance* is the wire or other resistance outside the battery; the *internal* resistance being that of the source itself. What is called "*polarisation*" is an *electro-plating* of the negative element (generally with hydrogen), which both lowers the electro-motive force, and augments the resistance of a battery. It is impossible to answer satisfactorily the question "which is the most constant, powerful, and durable battery"—that which is the best for one application is by no means necessarily the best for another. Your bichromate battery would probably be much improved by some arrangement for keeping the exciting fluid in agitation or circulation.

Fiat Lux.—On the 22nd inst. we attended, by invitation, at *The Times* office, in order to make an inspection of the invention you mention in connection with the electric light. Owing, however, to some misunderstanding between the occupiers of the premises and those who were to exhibit the light, no experiment could be made on the occasion in question *Vide* the commencement of our "Notes" this week.

The Phonograph.—We are informed that at present there is a little difficulty in obtaining this instrument. The Stereoscopic Company, Regent-street, has the exclusive license for this country; but, if our correspondent is unable to obtain what he requires from the company, he had better apply to Mr. Adams, 6, Lombard-street, E.C., Mr. Edison's representative here, for further information.

STUDENTS' COLUMN.

[The following paper, which deals with the theory of Wheatstone's Bridge, is the first of three papers by the same authors which originally appeared in the *Laboratory*. The paper has always seemed to us a most valuable one for students, and, as it is certainly not well known, we do not hesitate to reprint it.—Ed. E.]

ON THE DETERMINATION OF ELECTRICAL RESISTANCE.

BY C. HOCKIN, M.A., AND THE LATE A. MATTHIESSEN, F.R.S.

As the determination of this property is in many ways of great importance, it has been considered advisable to enter somewhat fully into the subject, for, as will be shown in a future communication, it will doubtless become of great practical value i

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determining the purity of metals, high temperatures, alloys for technical purposes, &c.

The method generally employed for the determination of the electrical resistance, or its reciprocal value, the electrical conducting power of metals, or alloys, is based on the following principle:—

Suppose a wire be bent round, and the ends soldered together (Fig. 1); now, if this wire be divided into two equal parts by connecting the terminals of a battery *a*, with A and B, the current entering from the battery at A will flow through A C B and A D B to B, and thence back to the battery. Now, the wire A C B is exactly equal in resistance to A D B, and, therefore, there being no choice for the current between A C B and A D B, it will divide itself equally, and one half will flow through A C B, and the other through A D B. Consider two points, *e* and *e'*, at equal distances from A. These points are situated exactly similarly in A C B and A D B, that is, in two equal wires through which the same current is flowing, and therefore the electrical state at *e* must be identically the same as at *e'*, and the pressure of the current (potential) at *e* is the same as it is at *e'*. If the points *e* and *e'* be joined together by a wire or by the two terminals of a galvanometer, it is sufficiently clear that no current will flow through the wire from *e* to *e'*, or from *e'* to *e*, as the points *e* and *e'*, being exactly in the same electrical state, there is no reason why the current should flow from *e* to *e'* rather than from *e'* to *e*. Instead of joining *e* with *e'*, suppose it be joined with another point, D, so that A D is not equal to A *c*. From reasonings similar to the above, it will not be possible to say whether, when *e* and D are joined together by a wire, a portion of it will flow from *e* to D, or *vice*

FIG. 1

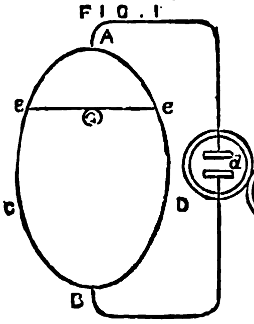
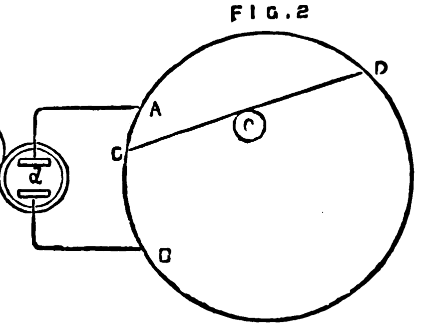


FIG. 2



versâ, or not. In order to find out this fact, it will be best to consider a more general case. Let a wire A D B C (Fig. 2) be bent, and the two terminals of a battery joined at A and B, so that A D B is greater than A C B. Before anything can be said as to the strength of the current in the branches A D B or A C B, it is necessary to know the law which regulates the relation between the amount of the current in the wire and the variations of pressure (tension or potential) in that wire. This law was first propounded by Ohm. It is as follows:—If in any wire, as in A C B, the potential at any point, say A, is equal to *a*, and at any other point C is equal to *c*, then the current flowing from A to C will be equal to (*a*—*c*), divided by the resistance of the wire A C (this may be written, for convenience sake, *r* (A to C). If C and D be joined together by a wire, the current passing through it may be determined by the above law, and will be found equal to $\frac{c-d}{r\,(\text{C to D})}$, where *c* and *d* represent the pressure of the current (potential) at C and D respectively, and *r* (C to D), as above, the resistance of the wire C D. This current, for reasons already shown, is wanted = 0, and this can only occur if $c = d$. When this is the case, then

The current in $\text{AC} = \frac{a-c}{r\,(\text{A to C})}$,

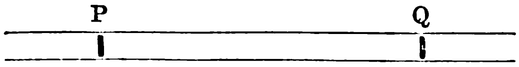
$$\text{CB} = \frac{c-b}{r\,(\text{C to B})},$$

$$\text{AD} = \frac{a-d}{r\,(\text{A to D})},$$

$$\text{DB} = \frac{d-b}{r\,(\text{D to B})}.$$

Now, since none of the current in *a c* branches off through C D, the current in C D must be equal to the current in *a c*, for a current is defined as the amount of electricity that flows through any wire in a given time.

Now, it is assumed that, in such wires as are now spoken of, the quantity of electricity that flows across any portion of the wire is the same; that is to say, that if P Q be a wire carrying a current—



the quantity of electricity entering the piece between P and Q at P is the same as the quantity that in the same time flows out through Q; in other words, there is no accumulation or loss of electricity in any portion of the wire, as P Q, during the time the current is flowing; and so, in the case of the wire A C B, the same quantity that in any time enters the wire at A must flow out at B; for we suppose that no electricity is lost or gained at the point C through the wire C D. In like manner, the current A D is equal to that in D B. This, therefore, leads to the following relations:—

$$\frac{a-c}{r\,(\text{A to C})} = \frac{c-b}{r\,(\text{C to B})} \text{ and } \frac{a-c}{r\,(\text{A to D})} = \frac{c-b}{r\,(\text{D to B})},$$

since we have assumed that $c = d$; whence

$$\frac{a-c}{c-b} = \frac{r\,(\text{A to C})}{r\,(\text{C to B})},\quad \frac{a-c}{c-b} = \frac{r\,(\text{A to D})}{r\,(\text{D to B})};$$

and therefore $$\frac{r\,(\text{A to C})}{r\,(\text{C to B})} = \frac{r\,(\text{A to D})}{r\,(\text{D to B})}. \quad \text{I.}$$

which may also be written—

$$r\,(\text{A to C}) : r\,(\text{A to D}) :: r\,(\text{C to B}) : r\,(\text{D to B}) \quad \text{II.}$$

which shows that, only when the resistances of the four branches are in this ratio, no portion of the current will flow from C to D, or from D to C, and, therefore, cause no deflection of the needle of a galvanometer whose terminals are brought in contact with the points D and C. The same result will be, of course, arrived at if in the above figures the four branches had been four separate wires soldered together, and the points of soldering connected with the battery and galvanometer.

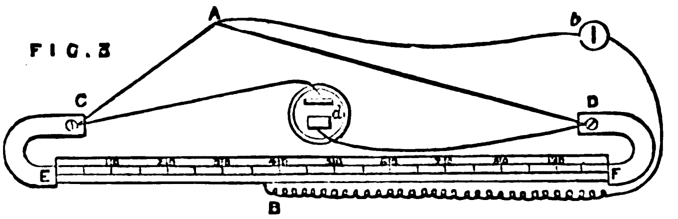
Supposing, now, an apparatus be constructed where the wire *e* B *e'* (Fig. 1) is divided into two equal parts, and where the wire A *e* is one of known resistance, then a wire may be placed between A and *e'*, and shortened or lengthened until no current passes through the galvanometer. When this takes place the resistance of the wire A *e'* will be equal to that of A *e*. This is obvious from formula I., which in this case will read $\frac{r\,(\text{A to } e)}{r\,(e \text{ to B})} = \frac{r\,(\text{A to } e')}{r\,(e' \text{ to B})}$.

Now, as the denominators of these fractions have been made equal, the numerators must, therefore, also be equal.

The above described apparatus is known under the name of Wheatstone's bridge or balance. It is obvious that, if we wish to make a resistance bearing any given proportion to any other resistance, we may do it in this way:—Let A C (Fig. 2) be our given wire, C B D another wire of any length. Suppose we wish to make a resistance ten times A C. We first take a point B in C B D such that BD is ten times B C, and then insert a wire between A and D, and vary its length until no current flows through C G D; when this is the case we know that A D will have the required resistance, namely, ten times the resistance of A C, for by formula I. $\frac{r\,(\text{A to C})}{r\,(\text{A to D})} = \frac{r\,(\text{C to B})}{r\,(\text{B to D})}$.

A balance constructed on this principle is shown in Fig. 3, which is, in fact, the practical carrying out of Fig. 2.

FIG. 3



Let A C be a wire of known resistance, A D the wire whose resistance is required; these are connected together at A by means of a binding screw, or mercury cup. At D and C they are connected with the wire at E F by means of binding screws and thick copper plates, C E and D F. The contact with the wire at B is a sliding one, and is arranged as follows:—At the bottom of a lead block is fixed a brass or platinum point, which rests on the wire, so that, by moving it backward or forward, the point of contact with the one terminal of the galvanometer B is altered, and the lengths of E B and F B will then vary according to the position of the block. By the side of the wire a scale is fixed, and in the lead block a pointer, with the help of which the position of the block can be read off. An example will help to show the use of this apparatus. Supposing the resistance of the wire to be determined, A D, be twice that of A C; then, on making contact with the battery, it will be found that, in all positions of the lead block, except when the pointer is opposite the number 333 (if the scale be divided into a thousand parts), the needle of the galvanometer will be deflected, and at that point the ratios, as before stated, of the two branches E B and B F, will be the ratios of the resistances A C and A D. The length of E B is 333 (say millimetres), that of F B 666, and which, therefore, gives the resistances of A C to

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B D as 1 to 2. Owing to the thickness of the copper plates C E and D F, their resistances may be neglected.

The wire E B F is generally a thick German silver one. The reason why German silver is used is that it is inexpensive, and that the influence of temperature on its resistance is small in comparison with that of the pure metals. With this arrangement it is clear that the ratio of the resistances of the wires A C and A D can be measured with no greater percentage accuracy than the smaller of the two distances B C or B D can be measured, and also that the accuracy of the result obtained will depend on the wire E B F being exactly of the same section throughout.

AWARDS AT THE PARIS EXHIBITION.

Class 65.—Telegraphic Apparatus for Processes.

England and Her Colonies.—Major Webber, R.E., Vice-President, Rue Gaston-Saint-Paul, 6.

France.—M. Becquerel (E.), Président, Rue Cuvier, 57; M. Bergon, Secretary-Reporter, Rue de Madame, 54.

— Supplementaries.—M. Baron, Rue de Madame, 64; M. Hocq, à Saint-Thomas-d'Aquin.

Name.	Address.	Award	Awarded for
Bell, A. G.	115, Cannon-st. London	G. P.	Magneto-electric telephone, without electric current.
British Telegraph Manufactory, Lim.	374, Euston-rd. London.	S.	Apparatus of various systems.
Jamieson, A.	Eastern Telegraph Co., L., 66, Old Broad-street, London	B.	Grappling apparatus for raising submarine cables.
Patent Nut & Bolt Co.	London Works, near Birmingham.	H.M.	Insulators for telegraph lines
Siemens Brothers	12, Qn. Anne's-gate, London.	G.	Improvements in apparatus, manufacture and laying of Atlantic cables.
Stroh	....	G.	
Telegraph Construction and Maintenance Co., Limited.	38, Old Broad-street, London	G.	Establishment of very great importance, having manufactured and laid the greater number of submarine telegraphs in existence, notably the first five Atlantic cables.
Varley, S. A.	Hatfield, Herts	H. M.	Apparatus for demagnetising needles of Wheatstone's telegraphs.
Zimdars, C.E.	327, Gray's Inn-road, London.	B.	Pneumatic signals for dwellings. Well studied arrangement.

THE ELECTRIC LIGHT IN LONDON.

Metropolitan Board of Works.

The following Report on the Electric Light was submitted to the Metropolitan Board of Works by the Works and General Purposes Committee on the 18th October:—

"Your committee have proceeded upon the resolution of the Board of June 28th last, referring it to them to consider and report as to the advisability of making an experiment with the eletcric light on the Victoria Embankment. In connection with this reference your committee have considered the letter referred by the Board on the 5th July last from Jules Gaudet, intimating his willingness to place before the Board all the information and details with regard to the mode of lighting the streets of London by electricity, as adopted by the Municipality of Paris. Your committee have also had before them communications from Mr. A. Apps, Mr. R. Applegarth, manager of the Electric Lighting Works, and Dr. R. Vassard, offering to supply information on the subject of the electric light. Your committee have conferred with your engineer and consulting chemist, and have received from those officers a report, in which they state that, having regard to the conflicting opinions which exist amongst those qualified to judge as to the present and future value and significance of the electric light, they consider it impossible to form a correct judgment as to its application, effects, and cost, without some considerable practical experience of its working. They therefore suggest that it would be desirable to make a large and continued experiment, and they propose that arrangements should be made to test the nature of the electric light along the whole length of the Victoria Embankment, a distance of about a mile and a quarter. They further suggest that, if it were thought desirable, the experiment might be extended to Waterloo Bridge, and they submit with their report a letter received from M. Jules Gaudet, the agent in London of the Société Générale d'Electricité, offering to contribute to the experiment in the following manner :—

"1. That a 20-light electric battery be placed at the service of the Metropolitan Board of Works on loan for a period of three months, to date from day of lighting up.

"2. That 20 Jablochkoff lamps, commutators, globes &c. &c., be supplied in like manner for like period.

"3. That an engineer and foreman of the Société Générale be appointed to superintend the erection and general organisation of the lighting apparatus.

"4. That the Société Générale supply the necessary quantity of 'candles.'

"5. That the Board of Works supply the motive power equal to 25 H.P., with driving wheel, necessary bands, &c., all in first-rate working order.

"6. That the Board of Works pay for all conductors (wires) and all standards for the lamps, materials, and labour for erection of same, also the travelling expenses, fees, and wages of the French engineer and foreman referred to for a period of 15 days, a competent engineer and foreman of their own being engaged on the job from the first.

"Your committee, having carefully considered the question, concur in the view that it is desirable to obtain practical experience of the working of the system, and they accordingly submit the following recommendation for adoption by the Board:— That arrangements be made to test the value of the electric light along the whole length of the Victoria Embankment, and subsequently, if considered desirable, upon Waterloo Bridge, and, with that view, that an offer which has been made by the Société Générale d'Electricité to assist the Board in carrying out the experiment by means of the Jablochkoff light, be accepted."

Mr. Richardson, in proposing the adoption of the recommendation of the committee, observed that there were few subjects exciting greater interest in the metropolis and throughout the country than the electric light. This Board, as the central governing body of the metropolis, would, he thought, feel it to be their duty to take an initiatory step in trying an experiment with the electric light. It was unreasonable to suppose that any of the local authorities should be prepared to incur the expense of such a trial; but this Board, having the Embankment under their charge, and having an offer from the Société Générale of the loan of the necessary apparatus, free of expense, for three months, the committee believed it right that the Board should take advantage of that offer, and incur the additional expense which was necessary for the wages of the officers employed, for the candles which would be burnt, and for keeping up the machinery. That would certainly involve expense to some little extent; but he thought that it would be well worthy of the Board to incur it, seeing that the object was to ascertain the value of the electric light. At the same time, the committee were well aware that the question was in its infancy, and that, no doubt, great improvements would be made in the course of time. He saw there was an amendment on the paper, asking the Board to wait until the value of those improvements should have been ascertained; and, in reply to that, he felt it necessary to remark that, if the Board were to wait for all these improvements, which would, doubtless, go on to the end of time, they would never do anything. It was necessary for a public board, in dealing with questions of this kind, to take the earliest opportunity that offered; and it was the very fact of their undertaking to test the matter for a time which would enable other persons to bring out their several improvements from time to time, and so perfect the work which was admittedly not perfect at present.

Mr. Munro seconded the proposal.

Mr. Leslie moved, as an amendment—"That any expenditure in relation thereto is premature in the absence of Lontin's and the probable great discovery by Edison of New York." Since the Board met this system had got into Chancery, and an injunction had been obtained against its use in London. In the circumstances, it was therefore impossible for them to apply the scheme before them, and they would have to wait till the question in dispute was settled by the Court. He quite agreed that they ought to try the electric light, but such action as that proposed was decidedly premature. The Lontin light, for instance, was being exhibited outside the Gaiety Theatre, and it was said that the cost was infinitely below the cost of the same amount of gas.

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When the subject was before the committee, he heard something about a number of new globes, but they were told that by Professor Edison's plan the present gas lamps, standards, &c., could be utilised. As trustees of the public money, he thought they ought to have an idea of what the cost of the proposed experiment would be before they committed themselves to it.

Dr. Brewer seconded the amendment.

Mr. Fell thought the light was capable of very great improvement, and was of opinion that, if the Board placed the light on the Embankment, and gave the public a specimen of it in its present stage of development, it would give an impetus to further improvements; and it would set scientific men thinking, and no doubt more developments perfecting the light would soon be brought before their notice. He thought it would be a great pity if the Board did not adopt the recommendation of the committee.

Mr. Richardson, in reply, reminded the Board that he did not propose to "adopt" the scheme, but simply to test it for three months. If they were not satisfied with it after the trial, they need not adopt it.

The Board then divided, when the amendment was lost by 15 to 4.

Mr. Legg hoped that the Board would pause before they carried the motion into force, and pledged themselves to an indefinite expense. If the Board adopted the recommendation of the committee, they would have to pay all the cost of supplying a steam-engine of the necessary horse power, conductors, wires, materials, engineers' fees, &c. He moved the adjournment of the debate for a week, and that, in the meantime, an estimate of the cost be laid before the Board.

Mr. Elt seconded this proposal, which was supported by Mr. Leslie, but Mr. Fowler spoke in favour of the adoption of the report, and Mr. Richardson remarked that the engineer (Sir Joseph Bazalgette) estimated the total cost to the Board of this experiment at 600*l.*

Mr. Jackson observed that the electric light was now exciting great interest throughout the country, and he thought the Board ought to take the initiatory step in testing its real value as soon as it conveniently could. The Corporation had decided to light up Billingsgate Market by this means, and he thought this Board ought not to be behind hand.

This second amendment, on being put, was also negatived, and the motion for the adoption of the committee's report was agreed to.

In addition to the experiments with the electric light to be carried out on the Thames Embankment, it was decided by the Commissioners of Sewers, on Tuesday, to test the light in front of the Mansion House and on the Holborn Viaduct. This course was resolved upon on the recommendation of Mr. Heywood, the City Engineer, who submitted to the Court an elaborate report upon the whole subject.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).

The third ordinary general meeting of the members of this Company was held on Wednesday, October 23, at the City Terminus Hotel, Cannon-street, under the presidency of Mr. C. W. Earle, the Chairman.

The report for the six months ending the 30th of June last stated that the amount to the credit of revenue was 41,511*l.* and the expenses had been 17,578*l.*, leaving a balance of 23,932*l.*, increased to 24,577*l.* by the amount brought forward from last half year. Of this sum the directors had added 5,000*l.* to the reserve fund, leaving 19,577*l.* available. They recommended the payment of the half year's dividends at the rate of 6 per cent. per annum on the first and second preference shares, and a dividend, tax free, at the rate of 1 per cent. per annum on the ordinary shares, leaving 3,391*l.* to be carried forward to next half year.

The Chairman, in moving the adoption of the report, said they that day showed a larger balance of revenue over expenditure than they had ever done; but the expenses of repairing the cable had been very much below the usual amount hitherto—it was generally 5,000*l.*, but in the first half year it had been under 2,000*l.*, and the difference between the two figures had turned the scale, and made the report present so favourable an appearan[illegible]hould be remembered, however, that the cost of the re[illegible]ble was a matter entirely beyond the directors' control. [illegible]atisfactory to observe a general decrease in the other ite[illegible]xpenditure, attributable, no doubt, to the vigilance exe[illegible] this matter. He regretted the falling off in the recei[illegible] messages, which was partly attributable to the very grea[illegible]sion of trade in the period under review, and which, th[illegible] might be only a passing influence; but, with regard to the coding, he was afraid there was very little hope of any improvement in the way in which they were affected by that system. In consideration of the Colonies allowing them to increase their rates, they had reduced the minimum number of words from ten to one, but the system of coding had been brought to such a pitch of excellence that the average number of words in a message had fallen off very considerably. Before they introduced the word system and the higher rates, the average number of words in a message was fifteen, but it was now under ten, without, it was to be remembered, a proportionate increase in the number of messages. Another cause of their smaller credit side was the cost of transmitting news to the Colonies. The past six months had been of great political importance throughout the world, and, in order to keep pace with the demands of the Colonies, they had been obliged to send nearly fifty per cent. more material than they had to do in quieter times. He regretted that this system was ever introduced into the West Indies, but it could not be helped now. It, however, involved them in considerable expense, besides trenching on their legitimate business. He then spoke of the service rendered by the Company's cable on the occasion of the Barbadoes riots, and more recently on the late outbreak in the Danish colony of St. Croix, observing that their wire was no doubt very instrumental in saving the property and probably the lives of a great number in that island. Considering, indeed, the important services performed by the company's undertaking to the Colonies, it seemed almost ridiculous that they should have to meet year after year with a very inadequate reserve fund and a dividend of 1 per cent. Sometimes, as regarded this, they were met with the remark that "Your capital is too large." True, it was originally 600,000*l.*, and it was now nearly double this amount, but this was through, in the first place, their including a greater number of islands at the request of the Colonies themselves, and it had also been found necessary to introduce the duplicate system. But still, he found that, taking six of the principal cable companies, the cost per mile of their lines had been 339*l.*, as against only 311*l.* per mile in the case of this Company; but, when he came to revenue, he found that the average receipts per mile from messages and subsidies in the case of the six companies was 39*l.* 5*s.*, whereas it was only 18*l.* 13*s.* in the case of this Company. This, in fact, was the point. Their revenue was inadequate either to keep up a proper reserve fund or to give a fair dividend, and it was on this ground that they had thought it right to make representations to the Secretary of State, and he hoped they would receive, as the right hon. gentleman had promised, fair and full consideration. He then moved the adoption of the report and the payment of the dividend recommended.

The motion having been seconded,

The Chairman, in reply to questions put by Mr. William Abbott, said that the coding system had certainly acted prejudicially in the case of this Company. With regard to the Central American Telegraph Company, he was informed that the lines beyond what they called the Central Company were so far from being perfect that, if the company was resuscitated, it would not be very much use to this Company. Hitherto, they had not been able to make any progress in this affair; they had tried, but had failed.

The motion was then unanimously passed, and a vote of thanks to the Chairman and Directors terminated the proceedings.

TELEGRAPH SHARE LIST.

Companies.	Closing Prices Oct. 23.		Business Done Week Ending Oct. 23. Highest.	Lowest.
Anglo-American	58½,	9	58½	58½ x div.
Do. Preferred	86¼,	¾	87	86½ x div.
Do. Deferred	32½,	3	32¾	31¾
Brazilian	6⅝,	⅞	6¾	6⅝
Cuba	8¼,	¾	—	—
Do. Ten per Cent. Preference	15¼,	¾	—	—
Direct Spanish	2,	½	—	—
Do. Ten per Cent. Preference	10,	½	10¼	10½
Direct United States	12⅜,	⅝	12½	12¼
Eastern	7,	¼	7¼	6⅞ x div.
Do. Six per Cent. Debenture	104,	7	—	— x div.
Do. Five per Cent. do.	99,	101	99½	99½ x div.
Do. Six per Cent. Preference	10¾,	11	11	10¾ x div.
Eastern Extension	6⅞,	7⅛	7 1-16	6⅞ x div.
Do. Six per Cent. Debenture	106,	9	107	107
German Union	7¾,	8¼	8	7¾
Globe Telegraph and Trust	4 13-16,	15-16	5	5 x div.
Do. Six per Cent. Preference	10¼,	⅝	10½	½ x div.
Great Northern	7¾,	8	—	—
Indo-European	20,	1	—	—
Mediterranean Extension	2⅞,	3	2 15-16	2 15-16
Do. Eight per Cent. Preference	9,	½	—	—
Reuter's	9¾,	10½	—	— x div.
Submarine	215,	220	—	—
West India and Panama	2,	¼	2¼	1-16
Do. Six per Cent. Preference	8¼,	¾	—	—
Western and Brazilian	2⅝,	⅞	2⅞	2⅝
West. Union Seven per Cent. 1st Mortgage	110,	15	111	111
Do. Six per Cent. Sterling	101,	3	—	—

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NOTES.

University College, Bristol.—Prof. S. P. Thompson will give during the term a course of lectures on the Technical Applications of Electricity.

The Meritens Machine.—It is rumoured that M. de Meritens, the inventor, has received, or is about to receive, the sum of three million francs for the French Patent.

Field Telegraphy.—According to the *Standard*, a field telegraph is in course of erection between Kohat and Thull. The first twenty-five miles from Kohat is already laid, and in working order.

Football at Birmingham.—A match was played on Monday night by the light of Jablochkoff's candles. It is said the result was so satisfactory that an order was given for the lighting of the Aston lower grounds permanently by means of these lights.

Divisibility of the Electric Light.—We hear that M. Jablochkoff, far from being satisfied with the electric candle bearing his name, is still pursuing an elaborate series of investigations for the purpose of obtaining a still more suitable means of producing the light.

The Eastern Extension Company.—Notice is given, as will be seen in our advertising columns, that the tenth Ordinary General Meeting will be held on Wednesday, November 6th. It seems that a detailed account of the recent negotiations with the Australian Colonies will be submitted to the meeting.

Progress of the Electric Light.—Mr Yates, a Liverpool electrician, has made a proposal to light the whole of Cork Town and Harbour by means of four electric lamps at a cost of under 5,000*l.*, including the engine and everything else. The position of the lamps would be as follows: one on Carlisle Fort, one on Spike Island, the third on Wilmount Castle, and the fourth on Spy-hill.

Meteorological Society.—The Council of this Society have arranged for a course of six lectures on Meteorology to be given at the Institution of Civil Engineers, 25, Great George-street, on successive Thursday evenings. The first lecture was delivered on Thursday, 31st October, by Dr. R. J. Mann, on "The Physical Properties of the Atmosphere." The fifth lecture, to be delivered on Nov. 28, by G. J. Symons, F.R.S., will be on Rain, Snow, Hail, and Atmospheric Electricity.

A New Metal.—M. Marc Delafontaine, after having been engaged for more than two years in researches on the samarskite earths, has discovered a new earth—making the fourth—belonging to the yttria group. This new earth occupies an intermediate position as to colour and weight between yttria and terbia, and it might, therefore, be supposed that it is only a mixture of those two bodies. But the numerous experiments M. Delafontaine has made lead him to conclude that this is not the case, and he, therefore, announces the discovery of the oxide of a new metal, to which he gives the name Phillippium (P_p.), in honour of M. P. Philippe Plantamour, of Geneva, the friend and pupil of Berzelius.

The Wallace Light.—At the meeting of the American Gas Light Association, Mr. Nettleton, speaking of the electric light, said that the Wallace electric candle was undoubtedly the best that has been made. The inventor lives in his town, and it is generally considered there that the electric light will be invaluable in all large establishments where work is done on coarse fabrics. But, where fine work is to be done, and in stores and dwellings, it can never be of practical use. A single wire is run around the Wallace Mill, and wherever they want to put a light they cut this wire and attach it. When one lamp is extinguished the others continue to burn. They have kept the light burning for ninety-six consecutive hours.—*New York Herald.*

The Telephone Suits.—The Bell Telephone Company has commenced suit in Cincinnati against C. E. Jones and Brother, and, on a preliminary hearing, the Court ordered an injunction to issue, unless the defendants gave bonds to respond to such damages as might be recovered against them. Such bond was subsequently given. In Boston suit has been commenced against one Hend, a maker of telephones. He was enjoined from the further manufacture of the instruments, and, on his continuing to solicit orders, the Court issued an order for him to show cause why he should not be punished for contempt. There is a suit against the agents of the Gold and Stock Telegraph Company in Boston and in New York—and another against J. Bunnell for making and selling telephones. We shall be glad to hear of a decision to these contests.

The Thermo-Electric Battery of M. Faure.—Some time ago Mr. Desmond Fitz-Gerald, M.S.T.E., made some careful experiments with the thermo-couple adopted by M. Faure, and very skilfully arranged by him in a novel and advantageous form. The electromotive force was found to vary, according to the temperature, from ·1059 to ·1547 volt; whilst the resistance of each couple was about $\frac{1}{200}$ ohm. This resistance, however, after a severe trial of the battery, with rapid variations of temperature, was found to become augmented; and the inventor was consequently called upon to modify the construction of the apparatus in such manner as to render it unaffected by the alternate heating and cooling to which it may be exposed. This, we are informed, he has succeeded in doing; the result being a thermo-battery, more powerful than any yet constructed, in a very practical form. We hope shortly to give a full account of this invention.

The Electric Light for Medical Examinations.—In a recent number of *La Nature* is an account of the electric polyscope described by M. Trouvé before the Physical Society of Paris, and intended for illuminating the mouth, the larynx, sphincter, &c. M. Trouvé employs a Planté secondary battery, regulated by a rhéostat of special construction, which enables him to maintain a platinum wire ·06 to 1·5 millimetres in diameter at the exact point of fusion for many hours. Connected with the poles of this battery are insulated wires, which, passing through a suitable handle, are fitted with binding screws. The circuit is completed by short wires attached to the binding screws and united at their free ends by the platinum wire, either shaped for cauterising purposes, or flattened into a disc suitably mounted in a reflector for giving light. This incandescent disc is said to give double the light of the platinum coil hitherto employed. The heat produced is much less than in the instrument used by Dr. Millot, of Paris, about 1868, in his experiments on illuminating the stomachs of animals.

American Electro-Plate in England.—On first appearances it seems somewhat strange that American manufactures should be successfully competing with Sheffield houses in the manufacture of silver-plated goods. Yet, really, it should not be a matter for suprise, for in America there are some of the best workmen whom Sheffield ever sent across the Atlantic. This, of course a great advantage in itself, is

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heightened by the large employment of labour-saving machinery, and the result of the combination is that the American goods have a smarter and more perfect appearance than have those made here. That American electro-plate, however, should find a market in England is certainly somewhat singular; but such is the fact. We hear of one or two large export houses that are buying American plate almost exclusively, and who have well nigh discarded the goods of Sheffield houses. That the trade is developing is evident from the fact that American travellers in this line visit England three or four times a year, and that their pattern books are freely distributed.—*British Mercantile Gazette.*

The Wallace-Farmer Machine. — Mr. Ladd, so well known himself in connection with dynamo-electric machines, has recently introduced into this country an improved form of the Wallace-Farmer machine. Our readers by referring to our earlier numbers will find that this was one of the machines tried by the Committee of the Franklin Institute, but, owing to a want of sufficient power, the experiments with the larger machine were discontinued. The designers of the machine claim to have made several alterations since the trials referred to, which add a good deal to its effectiveness. The machine consists of two uprights, on which and at right angles to the uprights are placed two masses of soft iron, surrounded by coils, the whole thus forming two horse-shoe electro-magnets. These magnets have their opposite poles facing each other, and constitute the field magnets. Between the poles are two sets of twenty-five smaller magnets fixed to a shaft which revolves between the arms of the horse-shoe magnets by means of bands at both ends. As the shaft revolves some 800 times a minute, the rotating magnets cut the fields 1,600 times per minute. A commutator is used for continuous currents, but arrangements are made to utilise the alternate currents. We hope to give a detailed account of this machine with diagrams in an early number.

Mr. Edison and the Electric Light.—In conversation last week with a reporter, Mr. Edison, speaking of electric light, said:—"I have let the other inventors get somewhat the start of me in this matter, because I have not given much attention to electric lights; but I believe I can catch up with them now. I have an idea that I can make the electric light available for all common uses, and supply it at a trifling cost compared with that of gas. There is no difficulty about dividing up the electric currents, and using small quantities at different points. The trouble is in finding a candle that will give a pleasant light, not too intense, which can be turned on or off as easily as gas. Such a candle cannot be made from carbon points, which waste away, and must be readjusted constantly while they do last. Some composition must be discovered which will be luminous when charged with electricity, and that will not waste away. A platinum wire gives a good light when a certain quantity of electricity is passed through it. If the current is made too strong, however, the wire will melt. I want to get something better. I have a chemist at work helping me to find the composition that will be made luminous by electricity. Now that I have a machine to make the electricity, I can experiment as much as I please. I think," he added, smiling, "there is where I can beat the other inventors, as I have so many facilities here for trying experiments." He added that he didn't care so much about making a fortune out of this matter as getting ahead of the "other fellows," and making something new. [illegible]ve is extracted from our American contemporary [illegible]tor, and contains a sentence of the utmost importa[illegible]one which should induce our companies to consider whether the example should be followed. Mr. Edison "has so many facilities for experiment." We are told his inventions produce an income of 60,000 dollars annually. Now, we think the company which in England would employ an able electrician, and give him experimental facilities, would not be long before reaping considerable benefit, and possibly as much renown as is obtained by our American friends. We have reason to believe that one of the companies lately formed to supply the electric light contemplates the employment of electricians for experimental work.

Liverpool and the Electric Light.—One of the subjects on the programme for the meeting of the Liverpool Town Council, on Wednesday, was the illumination of the streets by the electric light. The Gas Supply Committee recommend that the necessary Parliamentary notices be given of an application next Session for authority to "take all necessary steps, and execute the requisite works, for lighting the public streets and places and buildings within the borough by means of the electric light, and with power to supply such light to any person, or persons, or company who may require the same, and for further powers in connexion therewith." They also recommend that 2,000*l.* be granted towards the cost of a Bill, this being "for the public benefit of the inhabitants and the improvement of the borough." Dr. Cross (chairman of the committee) has given notice of motions to a like effect, with the addition that the corporation should have power to supply such light to any person or companies who may require the same, and for such further powers in connexion therewith, or with the gasworks, property, and undertaking of the Liverpool United Gas Light Company, as may be considered desirable. He will further move, that the Mayor be requested to convene a special meeting of the Council, to consider, and, if thought expedient, to direct the Parliamentary Committee to promote a Local Bill in Parliament for the purposes mentioned. Alderman Forwood has given notice of a motion, "That the borough and water engineer report to the Council with reference to the electric light and its applicability for lighting the public streets and places and buildings of the Corporation within the borough, and that he be authorised to examine the mode of lighting and appliances now in use in Paris, and to confer with the engineers of the City of London and of the Metropolitan Board of Works on the subject." It appears from the New York papers that a company has been started in New York called "The Edison Electric Light Company," with a capital of 300,000 dollars. The object of the company is stated generally to be "the production of heat, light, and power by electricity." The present object, however, is to supply a fund which is to assist Mr. Edison in carrying forward his experiments to a point where he shall give a positive demonstration of the powers of his new inventions. Precisely what these inventions are, in all their details of transmission of force and the multiplication of the light derived from electricity, Mr. Edison has not yet told to anybody, fearing that the devices may be patented abroad. The invention, as to the use of electric lights, it is said, will not include the use of carbon points, as ordinarily known in electric lights, but instead the incandescence of a metal simpler and cheaper in every way. Mr. Edison has determined upon the general features of his light, its manner of production, &c.; but, in many minor points connected with the distribution of the light for ordinary domestic and business purposes, much work has yet to be done. It was at first supposed that 100,000 dollars would be a sufficient experimental fund. but the larger amount was finally determined upon.

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MICROPHONE RECEIVERS.

By J. Laister, M.S.T.E.

So soon as the immediate excitement aroused by the microphone had calmed down, the chief practical interest was concentrated upon its capabilities as a transmitter of speech. It was evident that, if the ordinary microphone elements could be induced to give off articulate sound, or, failing this, if some other conducting material that would do so could be discovered without trespassing upon patent rights, we should secure a telephonic pair that for cheapness and simplicity could have no rival. In a word, we wanted a receiver which would render the microphone independent of the telephone. The task was inviting, and none the less so because of the prohibitive price put upon the last named instrument. It was very soon observed that the microphone did, indeed, under certain conditions, emit sounds, and it was barely a month old before we were told that this or that ingenious person had succeeded or was about to succeed in making a microphonic receiver. "In a week or two I shall inform your readers how to make the microphone speak without the help of a telephone," wrote one of these sanguine experimenters; "I have now proved beyond all question that the telephone can be dispensed with for receiving purposes," wrote another; and, week after week, this sort of pronouncement has been going on with very much flourish, but apparently with no enduring results. The truth seems to be that there is a general belief in its practicability, but that a good many persons are suffering from the inventing epidemic which has seized both amateurs and scientists like a gambling craze just now, and they incontinently shout "snap" for fear their friends the enemy should be first to cry "snip." Such a spectacle is, on this side of the Atlantic, unique in its way, and it may be worth while to estimate the real progress that has been made so far, and what are the indications of future success.

That a practically serviceable receiver for merely microphonic purposes, that is, for reproducing feeble sounds, can be constructed there is no manner of doubt. A multitude of different patterns have been suggested. Those that promise fairest to become receiver and transmitter, both in one—which is the combination aimed at—are essentially alike in that they affix one of the carbons, or a suitable substitute, to a non-metallic diaphragm. A receiver of this kind will reproduce sound when the microphone proper is actuated. But, if simple carbon is used, a condition of success would seem to be that make and break of contact take place either at the transmitter or the receiver. At present, it is doubtful whether the mere variation of an uninterrupted current will give off sounds in the receiver unless, on the other hand, the receiver itself is so adjusted that a spark results from an increase of current. It is obvious that these conditions are not favourable to the reproduction of articulate speech; and, as an adjunct of the microphone for all other purposes, such an appliance has no practical value, seeing than an extemporised telephone would answer very much better, and is not likely to be objected to by its patentees. We have heard of other kinds of receivers, and of one which has some pretensions to being successful, but the details are not made public, and we refrain from offering an opinion upon it until it has had a fair trial. On the whole, however, from the original cinder box to the latest thermophone, there is the strongest family likeness amongst these children of the brain—though the parents don't seem to see it—and it may be feared that all alike have had qualities hastily assigned to them which in the nature of things they can have little claim to.

To a certain extent, the foregoing observations apply also to another class of instrument, constructed on the assumption that repulsion takes place between the discontinuous points of contact when the current traverses them. But, if the alleged phenomenon is an ascertained fact, and if, further, repulsion occurs within the limits of actual contact—for break of contact is fatal to articulation—this line of investigation promises well. The heat producing property of the current also offers its temptations. Given a material that shall expand and contract with sufficient rapidity and precision in response to the varying intensity of the current, and perfect definition would be attainable. In this relation an ingenious correspondent of a contemporary some months ago hazarded an explanation of the microphone which is highly suggestive. "Carbon," said he "being a bad conductor of heat, such heat [generated by the current] is confined to the neighbourhood of the points [of contact] which causes them to expand and little nipples to jut out." Carbon may not be the only or the best material for the object under consideration, and it may be capable of taking a more serviceable form. We commend these hints to such of our readers as may be disposed to follow up the experiments in this direction.

We now come to a class of examples altogether different in respect to the means employed, although the object is the same. Electro-magnetism is brought into play in various ingenious ways, the details of which need not be entered into, as they have just now culminated in Mr. F. G. Lloyd's communication to *Nature*. This device consists of two electro-magnets, with opposing polarities facing each other, which, when disturbed by the action of a microphone included in the circuit, reproduces musical tones and, to some extent, it is alleged, articulate sounds. One can easily imagine the line of investigation which Mr. Lloyd has pursued to arrive at this curious result. It has long been known that an electro-magnet emits sound at the moment the current sets in and again at its cessation. It increases if the current is rapidly intermittent, and the inductive reaction between two opposing magnets would appear to increase not only the volume of sound, but its definition. Whatever the explanation may be, however, it is by no means certain that a receiver of this description would be permitted to invade the well-guarded domain of the telephone proper. If the instrument prove as successful as Mr. Lloyd anticipates, the fact brought to light is extremely interesting; but to us it appears that any forms of electro magnet whatsover—and certainly that form suggested in another quarter, consisting of a coil of wire affixed to a diaphragm, as also that with its core so affixed as proposed, again, in another—are all adaptations of Bell's principle, and, therefore, for commercial purposes, inadmissible. A suggestion has been made that experiments be tried without either core or diaphragm, that is to say, with the coil of wire simply. It is commonly alleged that the sounds from the electro-magnet are due to the expansion of the core; and we have it on high authority that expansion does really occur at the moment of magnetisation. But it is by no means certain that the accompanying sounds are caused by expansion solely. It is known that a freely suspended helix of wire through which a current is passing will place itself in the line of the dip; and there is reason to believe that a suspended bar of soft iron enveloped in a coil of wire gives a distinct "kick" to the right or the left under the magnetic direction of the current. Further, there is attraction and repulsion, as well as expansion, between the coils of wire, and also between the several layers. When a microphone is used—as, with a little ingenuity it conveniently may—to detect these movements and determine their direction, the fact becomes evident that, if a coil of conducting wire is free to move, it will move silently, but, if mechanically prevented moving freely, it will make a noise. If this phenomenon has the significance ascribed to it, there is the possibility that a coil or coils of wire alone will give results akin to those obtained by means of electro-magnets complete. What kind of wire it would be best to use, how it should be wound, and how coated and secured, are points which, as we do not lay claim to the inventive faculty, may be left to the judgment and patience of each experimenter.

To sum up, there are at present two, and, so far as is made public, only two distinct classes of microphone receivers in the field; the one utilising the thermo, or the repelling properties of the current, the other relying upon the effects of current magnetism. The former, using as it does materials which are themselves microphonic, would, if successful, make the microphone self-dependent like the telephone, and would assuredly invade no patent rights. The latter class could barely evade a legal obstruction, and would, in any case, if used for profit, be an unfair adaptation of a principle to which no one can grudge Professor Bell the exclusive right. If, however, any system of this kind might be used with honour as well as safety, it would, we think, be the sonorous properties of conducting wires. We commenced by saying that none of these contrivances had yet obtained a recognised footing of success, and we would add, in conclusion, that the difficulty of the task has been all along underrated. It has been forgotten that for the wonderful revelations of the microphone we are entirely indebted to the telephone; for the marvel is not so much that variations of conductivity arise at loose contacts as that the telephone reproduces every shade of such variation; and nothing falling short of that refinement, sensibility, and precision of the telephone can hope to rival it as a microphone receiver.

Formulæ Applicable to the Electric Light.—We are promised next week a set of simple *formulæ*, which may be of use to the electrical engineer in the work connected with electric lighting. Some of these expressions, no doubt, can be applicable only under particular and ascertained conditions; but others—such as those for the energy or horse-power absorbed by a given current, and in the voltaic arc itself—should, we think, be absolute. We shall be glad to hear from any of our readers who may have condensed their experimental data into the same convenient form.

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GALVANOMETERS.—III.

By J. T. Sprague, M.S.T.E.

(continued from page 177.)

The Tangent Galvanometer.—If a wire be bent into a rectangular form, as in Fig. 1, p. 177, and the magnetic needle be suspended in the middle, it is obvious that all parts of the wire exert their energy to pull the needle in one direction. A circular wire, being the same in principle, will have a like action, with this additional advantage, that all parts of it being equi-distant from the centre its actions would be equal upon a resistance, *i.e.*, a magnet pole, at the centre of the circle. The pole, it is true, cannot be placed at the centre, because we cannot obtain a single pole, but, if the magnetic field set up by the galvanic current is so large that it is practically equal in force at all the parts which can be occupied by the moving needle, then the result is the same as if the reacting pole were in the centre. We shall have occasion to return to this subject when considering other forms of galvanometer, so that I will only remark here that all the theories and laws set forth as to the influence of distance of the wire from the needle resolve themselves simply into this one point, the distribution of force in the magnetic field due to the currents in the wires. Unfortunately, as with many other highly wrought mathematical formulæ, they too often tend to hide away out of sight the real principle which gives them existence. For this reason, I prefer to commence with consideration of the Tangent galvanometer, because in it are most readily traceable the physical principles at work in all the other forms. In it, then, the desired result is attained by making the circle of wire so large in proportion to the motion of the pole, that is, to the length of the moving magnet, that this motion does not materially affect the relations between the current and the pole, or, as mathematicians would say, that the motion occurs in an equipotential line or field. Therefore, the larger the wire circle, and the shorter the needle, the more exactly these conditions are fulfilled. The diameter of the circle should be at least ten times the length of the needle.

When a magnet is suspended simply in the magnetic field of the earth, it stands magnetic North and South, which is called the zero line.

When the magnetic field of the earth is obliterated in the neighbourhood of the needle, as by means of external magnets, or its influence is put an end to, as in a perfectly astatic needle, the magnet has no directive influence whatever, though it is often erroneously supposed to place itself E. and W., and then, under the influence of any electric current, it places itself in the zero of the field due to this current, that is, if the wire be placed in the magnetic zero line, the needle places itself at right angles, or at 90° of deflection.

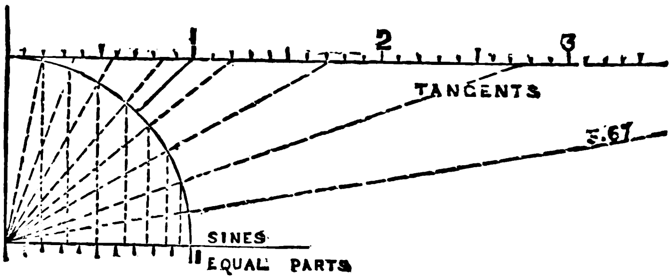
When an ordinary single needle is placed at the centre of a current moving in the plane of the magnetic meridian, this needle is deflected to a certain degree dependent upon the strength of the current. In this position it is influenced by *two equal and opposite forces*, the valuation of either one of which, therefore, [illegible]es the other.

[illegible] these two forces one is known—that is to say, the action of [illegible]earth's magnetic field upon the needle, and, if we can express [illegible] force in some [illegible] system, we have equally the measure [illegible], which, in the given circumstances, [illegible].

[illegible] magnet whose power is not exactly [illegible] direction of its poles is also subject to varia[illegible]s, some known and regular, others uncertain and transitory. [illegible]se latter we need not consider.

[illegible]he influences of these two forces are, according to known [illegible], proportional to the sines of their relative angles, that is to [illegible] considering the one angle of deflection alone, the pull of the [illegible]h's field upon the needle is proportional to the angle of deflec[illegible], while the pull of the current is equal to the co-sine of the [illegible]e angle. To value these trigonometrical expressions, how[illegible], we must attach some definite measurement to them, [illegible]use the unit pulls of the two forces are not the same. This [illegible]ct is attained by different writers by various formulæ of [illegible]h I will quote one from "De la Rive," vol. i., p. 338, as [illegible]g about the simplest:—"Now, by supposing that the angle [illegible]eviation described by the needle under the action of a current [illegible], the force which tends to bring it back into the magnetic meridian, and which produces equilibrium to the deviating action of the current, would be f sine i, f being the force of the terrestrial magnetism for the angle whose sine is 1, viz., for the angle of 90°. On the other hand, if F represents the action of the current upon the needle, when the latter is placed parallel to the current, this force will become F cosine i, when the needle makes an angle i, with the direction of the current; for F cosine i is the component of F acting under the angle i. F cosine i, therefore, is the expression of the deviating force of the current upon the needle, when the angle of deviation is i; it is, consequently, equal to f sine i, since it makes equilibrium with it. From F cosine $i = f$ sine i we deduce $F = f\frac{\text{sine } i}{\text{cosine } i.} = \tan. i.$ But f is a constant quantity, at least in the place where the observation is made, because it is the directive force of the earth. Therefore F, or the force of the current, is proportional to the tangent of i, or of the angle of deviation."

I prefer to make principles comprehensible, and evident if possible to the eye, and therefore I have worked out the following explanation. Instead of considering the two forces as *pulls* at right angles, which necessitates the consideration of the sine and the cosine of the angle of deviation, two measures, which except at 45° are *unequal*, while the forces they measure are *equal*, let us, remembering that the earth's magnetism and the current are acting from the same plane, treat one as a *pull* and the other as a *push* of equal power; *we now measure them both at once*, they are both equal to the sine of the angle of deviation. Let us now commit a mathematical heresy, and declare that the sine of an angle and the tangent of an angle are the same thing; but in doing so let me ask any critic who may notice this assertion *not to quote it without its context*. The figure below will show, in fact, that the tangent is a line parallel to the sine (therefore, fairly expressing the same forces), but cut by a wider arc. The measure of the sine is defined by the unit radius; that is, the sine of 90° and the radius are both 1, the sine of any angle being the line parallel to that radius, and defined in length by the arc measuring the angle of deviation. The line of tangents is another line, also parallel to the radius line of 90° and to all sines of all the angles extending from the initial point of the arc to which it is tangential; its unit of measure is also the radius or sine of 90°, but it corresponds here to the angle of 45°, its length being defined by the extension of the further side of the angle, which side, or line extending from the centre through the end of the measuring arc till it meets the tangent line, is called the secant. The sine of an angle and the tangent are thus only two measures of the same thing indicated also by the arc or by its chord, but the line of tangents has the valuable property of being exactly proportional quantitatively to those forces which cause deflections, but which mathematicians prefer to express as proportional to the scale of sines which is not one of equal parts.



The figure is divided into arcs of 10°, and is provided with scales of equal parts to both the lines of tangents and of sines. I give below a list of corresponding natural tangents and sines, and it will be seen that the lines forming the sides of the angles cut the tangential lines at the parts of the scale corresponding to these values, while perpendiculars dropped from their intersections of the arc cut the scale of sines equally.

Another mode of expressing the matter is this. Making the radius unity, or a constant, we get the forces expressed in a constantly diminishing pair of scales, the sines, or the chords, of the angles of deflection. By using the secant of the angle as a secondary radius, we expand the scale of sines into one which expresses, on the line of tangents, the acting forces as equal proportional measures.

	Natural sines.	Tangents.
10°	·174	·176
20	·342	·364
30	·500	·577
40	·643	·839
45	·707	1·000
50	·766	1·192
60	·866	1·732
70	·940	2·747
80	·985	5·671
90	1·000	Infinite.

Query.—A correspondent wishes to know the English term for and the composition of the mixture termed by French druggists *sel* or *fiel de verre*, and used with the zinc-carbon battery of M. Jourdan.

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PARIS EXHIBITION.—IV.

We should have stated that the Weston machine described in our columns last week has been exhibited in the American section, and that its great usefulness for nickel plating purposes has been shown by its daily work. At the same time, we may say that the Gramme and other machines can be and are used for plating purposes. We saw a Gramme machine at such work in the atelier of M. Breguet. It is said, however, that for these purposes the Weston machine is the best adapted and the most economical. An invention that possesses a considerable amount of merit is the fire alarm of M. Leblan. An invention of this kind appeals directly to us all, for everyone understands the value of knowing at an early moment of the outbreak of a fire. In almost every case the danger from fire consists in our ignorance of its beginnings. The accidental combustion of very inflammable material, of course, puts it almost out of our power to deal single handed with the enemy, but under ordinary circumstances a jug of water is amply sufficient to avert loss and danger. M. Leblan gives us a simple apparatus, which acts automatically, and gives an alarm whenever there is a sudden addition to the ordinary heat of the atmosphere in which it is placed. He proceeds upon the knowledge that such materials as felt, wool, &c., do not offer a great resistance to the passage of heat that varies the temperature very gradually, but do offer a great resistance to a sudden rise in temperature. He therefore takes two similar plates of zinc, rigidly fastens them at one end, allowing free motion to the other. One plate is covered with felt or wool, or some such material; the other is not covered. At the end of the latter plate is a small platinum spring; the former is in connection, but not in contact, with a moveable screw, which is connected to the battery, the plate being separated from the screw by a small piece of non-conducting material. The circuit is broken so long as the moveable platinum spring is not in contact with the screw. A bell is placed at some convenient point in the circuit, so that whenever sounded it may be heard. Now, when the heat received by the two plates is gradual, both the covered and the uncovered one expand at the same rate, and the platinum spring retains its normal distance from the binding screw. When the temperature is suddenly raised, the sheath on the one plate being a non-conductor of heat, retards the expansion of that plate, while the other rapidly expands, and pushes the spring into contact with the screw, thus completing the circuit, and causing an alarm to be sounded. The zinc plates used are ·6 m. by ·05 m.; and as the expansion of zinc is very small, the adjustments must be carefully made. According to Tyndall ("Heat, a Mode of Motion," p. 92), the linear coefficient of expansion of zinc is ·0000294 for 1° C., so that the distance of the platinum spring from the contact screen must necessarily be extremely minute, and, consequently, the adjustment is a very delicate affair. M. Leblan, following in the footsteps of other able mechanicians, deals satisfactorily with these small distances. His moveable screw is fitted with a large milled head, having 120 teeth, and the clicking of a small clutch tells how far the screw has been moved. The experiments of M Leblan gives four turns of the screw as the equivalent to the expansion of the zinc 1° C.

The Tommasi Relay exhibited by M. F. Tommasi is deserving of considerable attention. The electro-magnet bears a certain resemblance to that used by Faraday in studying the rotation of polarised light under the influence of magnetism; only the cross-piece which connects the two polar branches which are opposed to each other is, like the latter, surrounded by a helical coil. The magnetic bar intended to influence the contacts of the relay is disposed between the poles of this electro-magnet. This bar, or rather this magnetic system—for there are two bars which are parallel to each other—is of very small mass and length. The latter should not exceed the diameter of the polar extremities of the electro-magnet. Each of the magnets is pivoted about its centre, and carries a small cleat, the object of which is to produce a jar sufficient to prevent the contacts from sticking, and to quicken the movements of the system. Normally, these bars are held in the plane of the equatorial line of the electro-magnet by a fixed magnet, of which the acting pole is pointed; but, when the current traverses the electro-magnet, each of its poles reacts on the magnetic system at once by attraction and repulsion, and tends to deflect it on either side according to the direction of the current. Thus, the magnetic system, which is disposed between these two contacts of the relay, strikes against one or the other of the contacts, and brings into action the local battery which is intended to work the instrument connected with the relay.

This relay acts with reverse currents, and has been arranged so as to be applicable to the Morse or to the Hughes telegraphs; it is so sensitive as to be influenced by a current from a voltaic couple formed of a zinc and a copper wire, immersed in pure water, even after this current has traversed a board of dry wood 20 centimetres in length.

We have before us the report of a well-known English electrician on this relay. Some experiments have been made with this relay on the French Atlantic Cable. The signals were sent by the ordinary mirror, and received by the mirror of M. Tommasi, which he states is more sensitive than that of Thomson. It is doubtful, however, if these experiments, although fairly successful, can be taken as having proved the superiority of this instrument. There is no doubt it is a very sensitive relay, but it does not possess the advantage of a moveable zero. M. Tommasi, in "the first place, proposes to work the Hughes Roman type printer with his improvements; secondly, by fixing a key to the same instrument, to work Morse, and, failing both, to work mirror. He depends upon his superiority in sending upon a plan of curbing the signals exactly as I (the writer of the report) and others have been at work at." The report goes on to intimate that probably no great speed will be obtained from such combination with the Hughes instrument, or from working with the Morse, but that it is at present impossible to say exactly what can be done, as the instrument has not yet been sufficiently tested. We are sorry that the regulations prevent us giving a sketch of the instrument, but hope to be able to do this independently of the Exhibition.

CORRESPONDENCE.

THE ARNAUD SYSTEM OF DIVIDING THE ELECTRIC LIGHT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of the 26th inst. you published a Note which might lead the public into a gross error concerning my invention.

The strips of platinum, of which you speak, have nothing whatever to do with the process, and I made use of them only because they permitted me to make experiments that no one else, up to the present time, has been able to make.

My system may be briefly described thus. An electric circuit being given, if I interpose a number of lamps according to the electric force at my disposal, *between* the two conductors of this circuit, I obtain a series of circuits closed on each lamp, and of which the resistance increases in proportion to the length.

If I circulate an ordinary current in the conductors, and if, for experiment, I use strips of platinum, the nearest lamp to the battery will melt instantly; but, as soon as I send my divided current in the lamps, the platinum wires become incandescent and of the same intensity.

In the experiment to which you referred I went further. I established a circuit of No. 20 cotton-covered copper wire 200 yards long, the resistance of which being, I think, equivalent to more than two miles of an ordinary telegraph wire. To each of the extremities of this circuit I placed a fine platinum wire, and, when the divided current was passed into the circuit, the platinum wires were illuminated in exactly the same degree. In substituting an ordinary for the divided current, the platinum wire nearest the battery burnt instantaneously.

I add that my system of divisibility does not increase in the slightest degree the resistance of the circuit, but rather to the contrary; and my lamps, although they obtain their electricity from a common source, are independent of each other, so that the extinction of one or several of them, does not affect the rest.

As you may now see, this is something more than the mere substitution of strips of platinum for the ordinary carbon rods, as one was led to believe by reading your remarks.

I am not acquainted with Mr. Edison's process, but, as far as divisibility is concerned, I doubt that he is able to insert a galvanometer in the circuit of each of his lamps, and to show by the deflection of the needle that current of equal intensity traverses them all. That, however, is what I do. Excuse me, sir, for these rather lengthy explanations, and believe me yours faithfully,

ANT. ARNAUD.

P.S.—Years ago, I have tried many experiments with asbestos, as you suggest, but I found that it burnt before sufficient light was obtained.

[In our note we intended to indicate simply that platinum was used in the incandescent state to give light, without any reference to the method by which the division of the light was obtained. We quite believe that Mr. Arnaud has a very simple system of dividing the light, and this is what he claims as original.—ED. E.]

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THE ELECTRICIAN.

TO CORRESPONDENTS.

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All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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NOTICE TO EDITORS.

We shall be happy to exchange with the Editors of Scientific journals who receive the first numbers of THE ELECTRICIAN.

Nous serons heureux de faire l'échange avec Messieurs les Rédacteurs des Journaux scientifiques qui recevront les premiers numéros de L'ELECTRICIAN.

Es wird uns ein Vergnügen sein mit den löblichen Redactionen der deutschen und anderen continentalen Journäle und Zeitschriften, denen die ersten Nos. des ELECTRICIAN *zu Händen kommen möchten auszutauschen.*

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INTERNATIONAL CO-OPERATION IN THE APPLICATIONS OF ELECTRICITY.

It has been well said that there are two sciences of electricity:—that, having a strikingly conservative tendency, of the text books and scholastic authorities, and that of the telegraph engineer, which, driven by necessity, is constantly innovating, ignoring old points of view, and getting ahead of the other. In a manner which is not at all analogous, European electrical science, in its more practical aspect, might, perhaps, be superficially divided into English and French electrical science. True, there are the German scientists and engineers—many contributors to the *Annalen* of Poggendorff—to whom we owe so much, either directly or indirectly. But German science, where it is not abstruse, is eclectic, and one, at least, of the foremost electricians and electrical engineers of German nationality is claimed, and has, in fact, been appropriated by this country; so that the German electricians have come to be considered by many as belonging to the English school of electricity, though some amongst themselves may accept the proposition *vice versâ*. Between English and French electrical science it would be difficult to establish any broad distinctive differences, although there are differences—by no means of an invidious character—which are sufficiently well marked to those who frequently cross and re-cross the Channel in pursuit of electrical knowledge. The fact that we islanders have had the construction of nearly all the submarine cables of the world has been so great an advantage to us that it is scarcely to be wondered at if English electricians should sometimes observe in their French brethren a want of familiarity with such matters as the static phenomena of voltaic electricity on a large scale, or the use of condensers in certain delicate operations of testing, and with such terms as "microfarad," "inductive resistance," or "absolute electro-magnetic units." On the other hand, the exceptional neatness, ingenuity, and enterprise, which distinguish the French *mécanicien* or *constructeur*, no less than the electrical engineer of the same nationality, may be taken as some explanation of the fact that the best magneto-electric machines, electrical apparatus for surgical use, electric lamps and carbons for use therewith, &c., &c., come from France. In truth, the English electrician has, in many departments of his work, something to learn of his French *confrère*, and the converse proposition is equally true. We often need to obtain *matériel*, ideas, and even men of special talent from across the Channel; and it would often be to our advantage, as well as to that of our neighbours, if we could, with greater facility, place our *spécialités* before them. We do not require several schools of electrical science and practice, but to blend all schools into one by continual intercommunications. And whatever facilitates intercourse between men of science, men of practice, and buyers and sellers of different nationalities, must necessarily, in electrical applications as well as in other directions, contribute materially to progress.

It is for these reasons that we welcome the project of an International Electrical Agency which has been put forward by our Parisian contemporary, *l'Electricité*. L'AGENCE INTERNATIONALE DE L'ELECTRICITE, which is about to be established in Paris, will, we are informed, have for its sole object to encourage all the applications of electricity to the arts and manufactures, and to those purposes of public and domestic importance to which the sphere of its utility may be extended. It will seek to popularise and to perfect these applications by various means that may be found conducive to the ends in view. Taking up a position in a central quarter of Paris, this company intends to form a permanent exhibition of instruments, apparatus, and machines, for the production and utilisation of electricity. Its programme includes, also, experimental demonstrations open to the public, a technical library, and an inquiry department, where special information may be obtained in connection with the above-mentioned applications. Established on a financial and commercial basis, although differing in many respects from an ordinary trade enterprise, it is intended to be not only self-supporting, but also profitable to all connected with it; and, in inviting British manufacturers, instrument-makers, mechanics, and engineers, to deposit with them articles or products for exhibition, the *Agence Internationale* gives it to be understood that these will be regarded in each case as temporary or permanent contributions, *pro ratâ* of their value, towards a legally-constituted company having more than adequate financial means.

We think that, under proper management, such an agency, of a cosmopolitan character and having branches in most of the European capitals, would have an extended sphere of usefulness, and might bring both profit and credit to those concerned in it. It would certainly obviate very many complaints we constantly hear, such as that of an experimenter who appeared to have expended a world of trouble in obtaining a few samples of the artificial carbon *crayons* of MM. Archereau, Gaudoin and Carré, and that of another student who despaired of ever being able to obtain the magneto-electric machine of M. Alfred Niaudet.

THOMSON AND HOUSTON'S ELECTRIC LIGHT.

Having been engaged in an extended series of experimental researches on dynamo-electric machines, and their application to electric lighting, our attention has been directed to the production of a system that will permit the use of a feebler current for producing an electric light than that ordinarily required, or, in

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other words, the use, when required, of a current of insufficient intensity to produce a continuous arc. At the same time, our system permits the use of a powerful current, in such a manner as to operate a considerable number of electric lamps placed in the same circuit.

As is well-known, when an electrical current which flows through a conductor of considerable length is suddenly broken, a bright flash, called the extra spark, appears at the point of separation. The extra spark will appear, although the current is not sufficient to sustain an arc of an appreciable length, at the point of separation.

In our system, one or both of the electrodes, which may be the ordinary carbon electrodes, are caused to vibrate to and from each other. The electrodes are placed at such a distance apart that in their motion towards each other they touch, and afterwards recede a distance apart, which can be regulated. These motions or vibrations are made to follow one another at such a rate that the effect of the light produced is continuous, for, as is well known, when flashes of light follow one another at a rate greater than twenty-five to thirty per second, the effect produced is that of a continuous light. The vibratory motions may be communicated to the electrodes by any suitable device, such, for example, as mechanism operated by a coiled spring, a weight, compressed air, &c., but it is evident that the current itself furnishes the most direct method of obtaining such motion, as by the use of an automatic vibrator, or an electric engine.

In practice, instead of vibrating both electrodes, we have found it necessary to give motion to but one, and, since the negative electrode may be made of such size as to waste very slowly, motion is imparted to it in preference to the positive. The carbon electrodes may be replaced by those of various substances of sufficient conducting power. In this system, when desired, an independent battery circuit is employed to control the extinction and lighting of each lamp. The following is a description of one of the forms of electric lamp which we have devised to be used in connection with our system of electric lighting:—

A flexible bar *b* of metal is firmly attached at one of its ends to a pillar *p*, and bears at its other end an iron armature *a*, placed opposite the adjustable polepiece of the electro-magnet *m*. A metal collar *c* supports the negative electrode, the positive

FIG. 1.

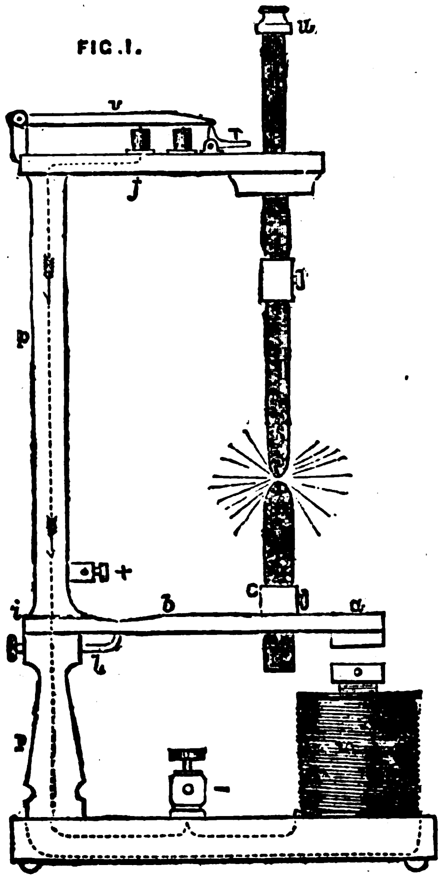
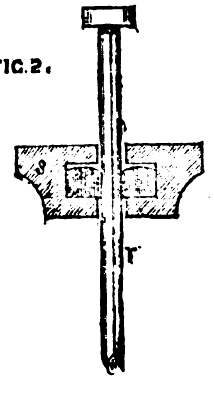


FIG. 2.



electrode being supported by an arm *j*, attached to the pillar *p*. The pillar *p* is divided by insulation at *i* into two sections, the upper one of which conveys the current from the binding post marked + to the arm *j*, and the rod *r* supporting the positive electrode.

The magnet *m* is placed as shown by the dotted lines in the circuit which produces the light. The pillar *p* is hollow, and has an insulated conducting wire enclosed, which connects the circuit *v* to the binding-post marked —. The current is conveyed to the negative electrode through *b* and the coils of the magnet *m*. When the electrodes are in contact, the current circulating through *m* renders it magnetic and attracts the armature *a*, thus separating the electrodes, when, on the weakening of the current, the elasticity of the rod *b* again restores the contact. During the movement of the negative electrode, since it is caused to occur many times per second, the positive electrode, though partially free to fall, cannot follow the rapid motions of the negative electrode, and, therefore, does not rest in permanent contact with it. The slow fall of the positive electrode may be insured either by properly proportioning its weight or by partly counterpoising it. The positive electrode thus becomes self-feeding.

The rapidity of movement of the negative carbon may be controlled by means of the rigid bar *l*, which acts, practically, to shorten or lengthen the part vibrating.

In order to obtain an excellent but free contact of the arm *j* with the positive electrode, the rod *r*, made of iron or other suitable metal, passes through a cavity *s*, Fig. 2, filled with mercury, placed in electrical contact with the arm *j*. Since the mercury does not wet the metal rod *r*, or the sides of the opening through which it passes, free movement of the rod is allowed without any escape of the mercury. We believe that this feature could be introduced advantageously into other forms of electric lamps.

In order to prevent a break from occurring in the circuit when the electrodes are consumed, a button *v* is attached to the upper extremity of the rod *r* at such a distance that when the carbons are consumed as much as is deemed desirable, it comes into contact with a tripping lever *t*, which then allows two conducting plugs attached to the bar *v* to fall into their respective mercury cups, attached respectively to the positive and negative binding posts by a direct wire. This action practically cuts the lamp out of the circuit.—*Journal of the Franklin Institute.*

PROFESSOR MORTON ON THE ELECTRIC LIGHT AND ITS POSSIBILITIES.

Professor Morton gave a lecture on, or, rather, an exhibition of the electric light at the Stevens Institute, in Hoboken, recently, before the American Gaslight Association. The gymnasium in which the lecture was held was well filled with a very attentive audience. The lecturer began by stating that it was his intention to say something as to the present and future developments of the electric light, and also to refer to its history. By the aid of stereopticon views Professor Morton described the various machines that had been invented during the past twenty years for the manufacture of the electric light. Among these were those of Messrs. Holmes, of England, the Alliance, and also the machine invented by Saxon, which was the first electric machine in America. Several of these were used in the English and French lighthouses and also at the Cherbourg docks. This was followed by a description of improvements on these machines by Siemens, Wild, Ladd, and Gramme, of England and France. The last named was said by the lecturer to be a very wonderful and admirable machine, perhaps not surpassed by any later one. Experiments were then given showing the illuminating power of this electric discharge, and the first of these was the introduction of two pieces of retort carbon into the lantern and "the actual self-produced image of the electric light" was then thrown upon the screen. The effect was exceedingly beautiful, and brought forth continuous applause. The naked electric light was then shown, and was so dazzling that the glare became quite painful and could only be endured by the audience for a few moments. The same light was then revealed protected by a globe, as exhibited at the American Institute and other places. In reference to the economy of this light, the Professor said that it was successful for the illumination of public grounds, large buildings or factories. For that purpose its adaptability had been fully tested. At present the only available material was carbon, which had been used in lamps, but had been found to waste away very quickly. When it was attempted to sub-divide the light the loss was found to be enormous. That was the rock upon which all the adapters of the electric light to the purposes now used by gas had always split. Twenty years ago, Jobart, a prominent member of the French Academy, presented a report in which all the present effect of the electric light was described. This was published in the *Gazette de France*. "This matter of dividing the electric light," said the Professor, "has not begun to be a practical success. As the matter stands to-day, there is a very large use for the electric light and sufficient to employ all

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the machines, but it is in the direction of lighting the sea shore or great public buildings. In the sub-division, as gas is now used, there is not even the prospect of anything being done. Even Mr. Edison says not for some years to come."

The lecture closed with an exhibition of a new gas burner, manufactured by Mr. Sugg, of London, England, that consisted of a triple series of rings, consuming little less than forty cubic feet of gas per hour, and equal to the light of 250 candles.—*New York Herald.*

THE *NEW YORK HERALD'S* REPORT OF MR. EDISON'S WORK.

The fierce denunciations of the gas companies at the latest discovery of Mr. Edison have produced no effect on the serenity of the Menlo Park laboratory. When Edison was told that eminent scientists and prominent gas company officials pronounced his alleged discovery concerning the electric light a sham, and offered to prove by figures and facts that division of the electric light to any practical extent was impossible, he smiled imperturbably and gave orders that a new eighty-horse power engine be at once placed in operation and that more workmen be added to the number already engaged in manufacturing the apparatus.

A *Herald* reporter recently visited the laboratory to learn the progress of the invention. Mr. Edison had gone to New York and was not expected back until night. His numerous workmen, however, were busily engaged at their different places. On the door leading in the laboratory the reporter noticed a large placard announcing that there was positively no admittance. It being such a striking departure from the usual freedom hitherto accorded all who visited the place, he asked an assistant the cause of the prohibition. "It's on account of the electric light," said the young man. "Since it became known that Mr. Edison had made his discovery the laboratory has been thronged at nearly all hours of the day with visitors anxious to see it. We were obliged to close the doors because the foreign patents have not yet been heard from. In a couple of weeks, however, perhaps less, all will be free again, and then the sceptics may see for themselves; but until then nobody will be allowed to see it."

"But scientific men say that the thing is impossible," observed the reporter.

"And so they said the quadruplex telegraph was impossible," answered the assistant. "Why, when Mr. Edison announced that he had succeeded in sending four messages on one wire at the same time in opposite directions, scientific men laughed outright and called him a madman. Again, when he said that he could talk through a telegraph wire, and in proof of the same showed his telephone, they would not believe it until they tried it over and over again and found it as he said; and again, when he said he would make it reproduce the human voice, they once more called him crazy. But, notwithstanding all they said, the phonograph, the telephone, and the quadruplex, are to-day admitted facts. Let them say what they please," continued the assistant, "we, who know what Mr. Edison is doing, are satisfied that he has succeeded."

EDISON.

At a late hour the Professor returned from New York. The reporter met him at the depôt, and asked him how he was progressing with the practical division of the electric light.

"Everything is going along all right," answered the inventor.

"Have you heard what scientific men say about it?" asked the reporter.

"What do they say?" inquired the inventor.

"That it is impossible."

"Well, we will see," was Mr. Edison's smiling rejoinder, as he prepared to go.

"They say that the electric light will not bear subdivision except at an enormous sacrifice of illuminating power," continued the writer.

"There is no sacrifice of power in this discovery," answered the inventor. "Those who are denouncing it as impossible are predicating on what they have not seen and do not understand. The invention is a new departure. I believe that I have succeeded beyond all doubt. In a little while all who doubt it may see for themselves. The assertions that are made in opposition are based on systems that have been tried and found defective. In a little while I will light up all the houses in Menlo Park, and then the scientific men can, if they desire, come and see. At present, however, I can say no more than that we are hard at work on it in the laboratory, and mean to lose no time." Bidding the reporter "Good night," the inventor then hurried to his laboratory.

TELEGRAPHIC EDUCATION.

We have received from Professor Adams, of King's College, a communication pointing out that, for more than ten years, an effort has been made at this College to supply students with the practical work and information described as required by telegraphists in our article of last week. He mentions that this was the first physical laboratory for students on a fairly large scale in England, that it is even older than the Oxford laboratory. It is gratifying to know that more than thirty students have been working in this laboratory at the same time, and we believe that several of the students of King's College have, by their after work, shown the great advantages to be obtained from such a course of study. The syllabus forwarded by Professor Adams contains a sketch of the course of work, and includes the following:—Magnetism and the Making of Magnets; Diamagnetism; Frictional Electricity; Manipulation of Electrical Machines and Apparatus connected with them; Electrometers and Electroscopes; Different Methods of Developing Currents of Electricity; Voltaic Electricity; The Use of Galvanometers; Measurement of the Strength of Currents; Measurement of the Electro-motive Force and Resistance of Batteries; Measuring the Resistance and Capacity of Wires and Cables; Electro-Magnetism; Current Induction; Magneto-Electric Induction; Absolute Measurement of Currents; Thermo-Electricity; the Electric Telegraph; Testing of Submarine Cables. Besides these Professor Adams has given special courses of lectures, adapted to the wants of telegraphists, on "Electrical Measurement and Telegraphy."

The following information relating to the work of the Japanese College at Tokei will be interesting, and will, perhaps, aid in the development of Telegraphic Education in England:—

REPORT on the Course of Telegraphic Engineering, Imperial College of Engineering, Tokei, 1st October, 1877:—

To Henry Dyer, Esq., Principal of the College.

DEAR SIR: Although on the continent of Europe professors of telegraphy have been for some time attached to certain of the technical universities, still in Great Britain the teaching of telegraphic engineering cannot yet be said to have been in any way organised. Schools for teaching mere signalling to telegraph operators undoubtedly exist, but it is, of course, not in the province of these to impart a technical education.

As far as I am aware all that has hitherto been done in Great Britain in the teaching of telegraphy (if we except the special training that individual telegraph engineers have received) may be summed up in the laboratory courses, on the principles of electrical measurement, given separately by Professors Sir Wm. Thomson and G. C. Foster, to certain students of the Indian Government Telegraph Department, and the practical course of construction given by Mr. Preece at Southampton to the same students, but none of these courses lasted sufficiently long for anything like a complete technical education to be imparted, so that they had to be continued in the testing rooms, workshops, and signal offices in India, and by learners being attached to all constructing parties in that country. And a similar remark applies to the lectures on electrical measurement delivered by Professor Fleeming Jenkin at University College, London, about the year 1867, since these, although of great value to the student of electricity, also necessarily confined themselves to a very small part of what should constitute the knowledge of a telegraph engineer. In telegraphy as in other branches of engineering it has been the custom in Great Britain for so-called pupils to be taken at telegraph manufactories, in many cases at a moderately high premium. Now, although the facilities thus offered to intelligent students to gain practical information by a daily study of the machinery and works are very great, and the comparative absence of instruction in any operations these students may perform calculated to lead to originality, still the principle that no regular instruction is imparted, and that the students are left to pick up what scraps of information they can, is likely to lead to irregular attendance and very slow progress in the case of the less bright pupils; consequently, such a system cannot be commended.

In 1873, the Japanese Government having been convinced that without a complete technical education it was impossible for a man to gain the acquirements necessary to enable him to construct, and work to the best advantage, even a land telegraph line, not to mention the more difficult problem—a submarine cable—decided on making telegraph engineering one of the professions open to the selection of the students of this college, and the aim has been, during the last four years, to impart to the students of this course such a knowledge of their own subject as would enable them to rank with civil, mechanical, and other engineers.

Consequently the telegraph engineers (who, during the first two years of the existence of the College, when all our own students

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were in the general course, consisted entirely of men sent by the Telegraph Department, afterwards partly of men belonging to that department and partly of our own third and fourth years students, and, lastly, at the present time, entirely of such students of the College) have been well practised in the construction and use of galvanometers, electrometers, resistance coils and condensers, &c., and in the performance of all the tests employed in a land line, or submarine cable testing office; artificial lines having been arranged, as far as practicable, with resistance coils, condensers, and a hundred yards or so of the Atlantic cable that were at our disposal. They have also been practically trained to execute all the ordinary electrical, mechanical, and chemical tests to which it is desirable to submit new telegraph material, and to make joints in iron and insulated wire. The Telegraph Museum (of which the preliminary catalogue has recently been published) although not nearly as complete as it is desirable that it should be, still has enabled the students to study the construction, working, and repairing of the more important signalling instruments, and, to a certain extent, the history of the development of telegraph apparatus.

The course of lectures given is seen from the following syllabus.

SYLLABUS OF THE COURSE OF TELEGRAPHIC ENGINEERING.

Those students who intend becoming telegraph engineers will, in addition to going through the complete course of Natural Philosophy marked (A.) (see the syllabus of Natural Philosophy), receive instruction in the following, by means of practical work and about two hundred lectures.

1. *History of the Telegraph.*—From the first published idea to the latest forms of telegraph instruments. (About thirty lectures).

2. *Construction of a line of Telegraph.*—(About twenty lectures) —Selection of route—posts, iron, wooden, stone—preparation, and preservation of wooden posts—simple rules regarding the use of stays, struts, and sole plates—wire, iron, steel, copper; jointing—laws connecting span, tension, and dip—insulators, choice of material and form—methods of testing them quantitatively—earth-plates; size, how they should be buried—building, and internal arrangement of signal offices—leading in wires.

3. *Working a line of Telegraph.*—(About thirty lectures) Different kinds of signalling and receiving instruments, their internal construction, the methods of adjusting and performing simple repairs—needle, Morse, bells (trembling, and single stroke), relays (ordinary, and Siemens' polarised)—step by step instruments; Bréguet's, Wheatstone's magneto-electric—chemical telegraphs; Bain's, fac-simile copying—automatic; Hughes', House's, Wheatstone's fast-speed—railway block system—batteries, best arrangement in different cases—protection of lines from lightning —duplex telegraphy—multiplex telegraphy—faults, earth, contact, break—quick methods for determining the nature of the fault—how to perform the regular tests of lines and batteries, and localise the positions of faults by means of a Wheatstone's bridge or differential galvanometer—calculations necessary to free the results from the effects of natural line currents, and normal defective insulation—military telegraphy.

4. *Submarine Cables.*—(About twenty lectures) Manufacture—jointing—sounding of bottom—laying of cable—working—retardation of signals—testing.

5. *Torpedoes.*—Construction—examination of different kinds—testing when laid—firing machines; galvanic, magneto-electric, frictional—how to avoid danger to friendly vessels from accident, carelessness, or the effects of natural terrestrial currents.

6. About one hundred lectures will be given in the following portion of the course of natural philosophy marked (B).

Magnetism. (B.) Unit pole—lines of force—magnetic potential—importance of knowledge of magnetic field in practical telegraphy—coefficient of magnetic induction.

Electricity. (B.) Exact measurement of electric quantity, density, resultant force, potential, electromotive force, capacity, current, and resistances—lines of force, and equipotential surfaces—electrostatic and electromagnetic systems of units—other systems—measurement of the action of currents on magnets, magnets on currents, and currents on currents—electrodynamometers—thermo-electricity, neutral points.

Students from the Telegraph Department who desire to obtain a technical knowledge of telegraphy, but who for special reasons have not time to go through the complete course of natural philosophy (A.) and (B.) will take up only course (A.) of magnetism and electricity, and as much of branches (1.) (2.) (3.) (4.) (5.) and (6.) of telegraphic engineering as their previous training renders possible.

The above lectures naturally divide themselves into two distinct heads, and on this account two distinct classes are held, both for the third year and for the fourth year telegraph engineers. In the former of each of these classes the subject matter of books like Culley's "Handbook of Practical Telegraphy," Sabine's "Electric Telegraph," &c., is taught; in the latter of the two classes Cumming's "Introduction to the Theory of Electricity," Fleeming Jenkin's "Electricity and Magnetism, and Clark and Sabine's "Electrical Tables," are more or less followed, the mathematical development of every formula in the latter being explained; and Clerk Maxwell's larger work on "Electricity and Magnetism" is also employed as far as the acquirements of the students will allow. I have, however, found it advisable to issue, in addition, printed notes for the guidance of the students in each of the four above mentioned technical classes.

During the early portion of the third year's course a considerable number of lectures have to be given by the professsor of telegraphy on analytical geometry and the differential and integral calculus, with which subject the students are not previously acquainted, and without a knowledge of which some of the simplest formulæ employed by telegraph engineers cannot be proved, or can only be proved in such a circuitous way as to involve the teaching of the differential and integral principles over and over again in every case. No greater mistake in the teaching of physical subjects can, I venture to think, be made than the one so rigidly adhered to of late years of attempting to use the differential and integral principles without employing the simplicity of the calculus (or mode of operation); or in imagining that good practical use cannot be made of the calculus without the student being first made familiar with the mysteries of elliptic integrals, and thoroughly mastering partial differential equations.

If the general course, instead of lasting two years as at present, could be extended to three, then an elementary knowledge of analytical geometry and the differential and integral calculus could be gained in the pure mathematical course, and the time now given by the professor of telegraphy to the teaching of these subjects could be spent better in the consideration of more purely electrical questions.

In addition to attending the technical lectures, and daily practising land line and cable testing the telegraph students have given most valuable assistance in that portion of the original work that has been undertaken in the physical laboratory connected with electricity and magnetism. For an account of this I beg to refer you to the section under Physical Laboratory in the Report on Natural Philosophy.

The plan hitherto followed of allowing the telegraph students to spend a few months every year in the actual construction of lines is much to be commended, and the excellent reports of the surveys made by them, as well as of the other practical work with which they have been connected, shows how highly they have appreciated the opportunities thus afforded them of applying in practice the theoretical knowledge gained in the class room and physical laboratory of this College. In addition, it would be very advantagous that a somewhat similar system should be extended to the electrician's branch of the Telegraph Department; so that it is extremely desirable that arrangements should be made for a large portion of the testing of artificial lines now performed in the physical laboratory to be replaced by actual testing of real lines under the direction of the professor of telegraphy; since, not only would the students learn better how to cope with practical difficulties, but the results so obtained would be of the greatest value to the Telegraph Department in the rapid determination of the position of interruptions, and in their speedy removal, as well as by the gradual improvement of all lines leaving Tokio, through the regular elimination of the parts found bad by testing.

It is, of course, too early yet to give many examples of the advantages that the Telegraph Department has gained by the existence of the technical course of telegraphy at this College. One of the first results, however, which followed from the establishment of this course was the institution of a complete system of *quantitatively* testing new insulators at the Telegraph Stores, Shiodome. This was of most vital importance, since, in spite of the fame attached to Japanese porcelain, which proved that good material was available, insulators of perfectly porous earthenware were being constructed.

As the students of telegraphy number among them some of the very best of the students of the College, great hopes may be held out that the Telegraph Department may in time become one of the most efficient branches of the Public Works Department, and may really attain to a moderately high standard of excellence. But this result will certainly not be achieved if the students, after leaving the College, do not receive the most careful supervision of skilled foreigners. For nothing can be conceived more detrimental to the success of a man, or to the success of the department to which he belongs, than his finding himself continually surrounded by men knowing very much less than himself, and this will necessarily be the result if the students mix only with less intelligent Japanese. Gradually forgetting, as is natural, their own great ignorance when compared with clever

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engineers, philosophers, &c., in Europe and America, whose very existence slowly passes out of their mind, no matter how vividly and constantly it may have been brought to their notice during their college course, they grow to think they know everything, that further study is unnecessary for them, and so they relapse into the orthodox small Japanese officer whose fancied knowledge is too vast to allow him to attend to trifles. Now, in no science can it be said with greater truth that success depends on trifles than in telegraphy, for the difference of the hundredth of an inch in the position of a wire means the difference between perfect contact and perfect insulation, or between a telegraph line in good working order and a total interruption. And, although an elaborate system of foreign supervision is undoubtedly contrary to the Japanese national spirit of independence, still, it is only by the existence of such a system that the students will themselves learn to supervise and to acquire those habits of responsibility which are at present quite unknown in this country; and it will not be until it is generally appreciated that what is everybody's work is no man's work that real success can be looked for in the Telegraph Department.

I am, yours truly,
(Signed) W. E. Ayrton,
Professor of Natural Philosophy and Telegraphy.

GENERAL CONSIDERATIONS ON TELEGRAPHIC TARIFFS.

(CONTINUED FROM PAGE 224.)

In the actual international system there are 86 telegrams out of 100 under the simple charge, about which the sender has no doubt, and which the overseer of the administration verifies at a glance. For the remaining 14 telegrams the application of the tariff is made by tens of words. The difficulties or errors in interpreting the regulations not being always of a nature to vary the charge, do not impede the speed of the operations, nor prevent the sender from himself prepaying by means of stamps, as he prepays the postage of his letters. This employment of stamps, which has become general in Belgium, is a very important result, which it is desirable to extend, and which should not be prevented where it is in use.

Let us suppose telegrams to be charged for per word, or letters charged for per gramme, and these facilities disappear. Every error modifies the charge. It is necessary to have recourse each time to a ready reckoner or to a calculation. In a home system where there is only a single charge by distance, either may be employed without too much delay.*

Would it be the same with a tariff varying according to the country?

Do not let us forget that these operations would have to be repeated in the verifications of the responsible chief of each office, in the checking at the central administration, and in the making out of the international accounts.

It is certain that the averages, which assist so greatly at the auditing of these accounts, would be much less readily struck if there were not 86 telegrams out of 100 at the same charge. In a word, the tariff rigorously graduated does not exist in any service either of transport or correspondence. Merchandise is not charged for by the kilogramme, nor remittances of money by the franc, nor letters by the gramme. When the maximum weight of the average letter was taken at 15 grammes, the object in view was not so much the reduction of the tariff as the necessity of including in the simple tax the greatest possible number of letters. In the same manner, if it was certain that no one would be indiscreet enough to send a telegram of more than 25 words there would be a reason to shut one's eyes to the last five words, and to charge the same for all telegrams without considering their length.

There must be a limit somewhere; hence the 15 grammes and the 20 words. It is very lucky for the administrations and for the public that nearly the whole of the messages remain on this side of that limit. We have here uniformity of charge, which is at least as desirable as uniformity for distance.

Let us mention, as a last argument, the telegrams of which the transmission is particularly difficult and laborious because the sender, with the object of reducing them to the simple charge, has suppressed the words which facilitate the meaning, or has used language previously agreed upon. In the actual system this case is restricted to messages allowing in their first drawing up of some words over 20. As for the others, there is no object in reducing them, since it is even advanced that the sender adds unnecessary words. This being the case, difficulties are avoided in the offices, at least for a good part of the traffic. It would no longer be the same when charging by the word; it would be to everybody's interest to reduce, and the negro language would became general.

These reasons having prevented the adoption of the tariff per word, the idea of classing telegrams under two heads, analogous to ordinary letters and to registered letters in the postal service, has been examined under conditions which we will refer to in a few words.

Ever since European telegraphy came into existence, it has offered to the public, in consideration of rather high surcharges, two accessory operations—repetition and the acknowledgment of receipt—which give to correspondents every guarantee of exactness and punctuality which practice makes possible.

To this offer, and to all the recommendations with which it has been accompanied, through publications, notices and otherwise, the public has invariably answered by abstaining from demanding the repetition and the acknowledgment of receipt, or, if it has demanded them, it is in a proportion so small that it is as good as saying that it does not wish for them.* One is obliged to conclude, either that it looks for cheapness before everything, or that it considers the ordinary conditions of the telegraphic service sufficient, or, lastly, that these two causes work simultaneously.

Such being the situation, if it were established that commercial telegraphy no longer found sufficient resources in its actual receipts, there would be two lines to choose from.

Either to raise, as much as might be necessary, the tariff of all messages, indiscriminately;

Or else to maintain the tariff at a low price for the generality of telegrams, taking away certain advantages which have been too liberally granted to them, and which would be reserved in the future for surcharged telegrams. These advantages would be, in addition to repetition and acknowledgement of receipt when asked for, the gratuitous transmission of the date and the hour of handing in; minute precautions in order to secure the delivery to the intending receiver, the transmission of notices of non-reception, the power of pre-paying the answer, the right of obtaining rectifications, the preservation of records, subsequent searches, the delivery of copies, and, lastly, the eventual repayment of the charge. It seems to us that the second alternative is by far the most liberal and most rational. It leaves to the public the option of cheapness when it is ready to content itself with ordinary proceedings. By making these less complicated and less laborious, it renders more frequent, it is true, the employment of guarantees on which a surcharge is made, but this new resource is legitimate, and injures fewer interests, taking it altogether, than a raising of the quota, less in amount but applicable to all messages indiscriminately.

It is ideas of this description which have prompted the royal decisions of the 8th April, 1874 (Art. 1 and 2), and of the 14th December, 1875, concerning the internal correspondence of Belgium, to which this system is, in a great measure, applied at the present day. But there is, in relation to this class of messages, an overwhelming argument in the deficit which they produce, as in nearly all the interior services of Europe. As this argument cannot be used *apropos* of international correspondence, which usually produces profits, the differential system, such as was first proposed at St. Petersburg, has met this very serious objection:—"It is not expedient to deprive the public of advantages and securities which it at present enjoys without giving to it, in compensation, some other advantage in the shape of a reduction of tariff or otherwise." In the face of this objection, and considering that the differential system under the form mentioned should, in order to succeed, be of general application, the proposition has been withdrawn; but it has reappeared under the form given to

* In Belgium, where the distances are short and rapidly passed over by travellers and by letters, the public has exigencies which are altogether peculiar in relation to promptitude. It is accustomed to great quickness in the operation of transmission when it does not pre-pay its messages itself without having recourse to the superintendent. These habits would be disturbed if they charged by the word, and it would be the same in England, if one may judge from the following extract from an article already mentioned:—"The committee seems favourable to that which is known as the charge per word. . . . This system we know is applied to the Atlantic cables; the committee delares that it has obtained great success, and that it is very popular. This popularity, in the limited portion of the public which uses the Atlantic cables, cannot be considered as a proof that the same system would be popular among the millions who use the Post Office telegraphs. It may be practicable with a very high minimum charge, as in the Atlantic cables. But it would be different with the thousands of telegrams at a half-penny a word. It seems to us that the moment we may depart from the uniform system in use we should meet with complications without end, requiring more *employés* to calculate the charges, more work [illegible] the receipts, and much more work for the central administration in verifying and controlling the accounts."

* Out of 708,716 international telegrams which circulated in Belgium in 1875, there were 134 repetitions (less than two in 10,000) and 57 receipts (eight in 100,000), not including 269 obligatory receipts, on account of the sender having demanded to pay the expenses of express.

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it by the Russian Government, and which has since been adopted as an optional arrangement by the St. Petersburg administration. This is *the telegraphic advice* of 10 words charged at three-fifths of the ordinary charge for 20 words. It cannot include either secret or prearranged language, or numbers written in figures. It does not allow of any extra operation, any preamble, or any information sent or written gratuitously.

The delivery to residence can be effected as for ordinary letters, and even without any envelope. The administration are not bound to deliver any receipt for it, to preserve it in the records, or to take any notice of complaints, or of applications for the return of money in relation to it.

These features are, indeed, those which the differential system would apply to ordinary telegrams, but they are accompanied by a reduction of 4 per cent., answering to the objection that this system has met with. Besides, in order to lessen the diminution of receipts and to meet the views which prompted the system of charging by the word, as well as the Italian proposal to apply to the telegram of 10 words one-half of the existing charge, the telegraphic advice has been reduced to 10 words. It is a measure of conciliation between the different ideas which were suggested with the object of realising progress without compromising the financial situation.*

The conference at St. Petersburg has likewise admitted as an optional course the introduction of the urgent despatch in international services—that is to say, priority, in consideration of a treble charge, over private telegrams which only pay the ordinary price. Nine offices out of nineteen have refused to adopt this from the date of Jan. 1, 1876.

The objections are always the same. *Urgency is a privilege granted to wealth.* However, the threefold rate of to-day is less than the majority of simple rates during the ten or fifteen first years of telegraphy. Was, then, the whole of this service, in comparison with the post, the privilege of large fortunes?

* Out of the 19 telegraphic administrations of Europe, 12 have refused or postponed the adoption of telegraphic advices. The following figures show the result of that adoption with respect to Belgium and the remaining six accepting offices, during the first three months of 1876:—

—		Austro-Hungary.	Spain.	France.	Holland.	Portugal.	Russia.
January.	Total number of telegrams exchanged	1,379	339	16,490	10,274	133	972
	Number of advices	3	1	70	378	1	,,
	Number of advices in 1,000 telegrams	2·2	2·9	4·2	36·8	7·5	,,
February.	Total number of telegrams exchanged	994	231	15,872	10,533	90	1,225
	Number of advices	4	2	90	519	2	,,
	Number of advices out of 1,000 telegrams	4	8·7	5·7	49·3	22·2	,,
March.	Total number of telegrams exchanged	1,160	309	14,960	10,270	130	970
	Number of advices	3	1	110	437	3	1
	Number of advices out of 1,000 telegrams	2·6	3·2	7·4	42·5	22·6	1

BRAZILIAN SUBMARINE TELEGRAPH COMPANY (LIMITED).

The tenth ordinary general meeting of shareholders of this company was held on Friday, October 25, at the Cannon-street Hotel, under the presidency of the Right Hon. Viscount Monck, the chairman.

Mr. RICHARD COLLETT, the secretary, having read the notice convening the meeting and the minutes of the ninth ordinary meeting of the company, held in May last, which were approved by the present meeting, and signed as correct by the chairman, the report of the directors for the half year ending the 30th of June last was taken as read. It detailed the financial results of six months' working—fully referred to below by the chairman—and stated that the Company's cables continued in good working order.

The noble CHAIRMAN, in moving the adoption of the report and the payment of a dividend, free of income-tax, of 2*s*. 6*d*. per share—making, with the interim dividends, 5 per cent. for the year—said: It is usual, in submitting this resolution, for the chairman to make some observations respecting the mode in which your business has been conducted during the half year to which the report alludes, and I am happy to be able to say that in doing that I shall not have to trouble you at any great length. The truth is, that our accounts are kept in that condition that every shareholder can see for himself, by looking at them, what the condition of the concern is. Gentlemen, the points on which you are concerned in reference to your undertaking are, first, the gross income derived from it; secondly, the expenses which are paid in order to obtain that income; and, thirdly, the disposition of the net income after deducting expenses. Well, gentlemen, the income for the half year with which we are now dealing is 72,086*l*. 14*s*. The income for the previous half year was 66,028*l*. showing a balance of 6,058*l*. in favour of this half year, ending the 30th of June, 1878, but I may mention that I do not think that that would be quite a fair mode of comparison, because our experience tells us that the second half of the year is always less productive than the first. As compared with the first half of the year, 1877, however, the half year ending on the 30th of June, 1878, shows an increment of only 1,976*l*., but that, though a small increase, is satisfactory so far because it shows that the traffic has increased in a small degree; and, considering, what I am sorry to say I have been obliged to allude to for several half years, the depression of trade all over the world, it is satisfactory to know that our business, at all events, is not participating so largely in the depression of trade as not to allow for a small increase in our receipts. Well, gentlemen, coming next to the working expenses of the line for the half year, ending June, 1878, they have been 14,166*l*. 16*s*. 8*d*,, as compared with 11,093*l*. for the previous half year. Of course, the same remark I have made as to the revenue does not apply to the expenses of each half year, which ought to be pretty nearly alike. There ought to be no great difference between the working expense of one half year and another. At first sight, therefore, an increase of 3,073*l*. in the expenses of the past half year over those of the previous half year looks a formidable sum, but it will be in your recollection that the Lisbon shore end of the cable got hooked by the anchor of a ship, as we believe, and we had to pay for the repair. That accident cost us 2,758*l*. which leaves the net increase of the expenses at only 315*l*. I may here mention, in a parenthesis, that we are not satisfied with the position of the shore end of the cable at Lisbon, and that we mean at some future period (we are prepared to do it now) to lay down a superior piece of cable in a rather different position, where it will be less liable to accidents from the anchorage of ships, and such matters; but we think that, though we are ready to do it at any moment, it is better for us to work the machine as long as it will go, and, therefore, till some fresh accident occurs we shall continue as we are at present. As long as the present cable continues to operate we shall use it, and not incur the expense of laying down a new shore end. As I have said, there is a net increase of 315*l*. in the expenses of the half year. Of this sum 262*l*. is for travelling expenses of some of the staff who have been five years in our service. Our contract with each man was for five years. At the end of that time he could leave us if he pleased, or receive a certain period of leave with a free passage home. I need not tell you that after five years' absence from one's friends and family, it is only right for them to return home [hear, hear]. I am happy to tell you that the whole of our staff have re-engaged with us, and I think the shareholders may consider themselves very fortunate in that circumstance. I have had occasion more than once to speak of the conduct of our staff, and I may say now, on the authority of our managing director beside me, that they are not only efficient and good men in the performance of their work, but that their conduct has been throughout unexceptionable in every respect [hear, hear]. That, I think, in itself is very satisfactory, and I do not think you will begrudge the money spent in allowing them a furlough at home after their five years' service [hear, hear]. Well, gentlemen, I now come to the mode in which we have distributed the money we have taken. You will see that the gross income, as I have stated, was 72,086*l*. 14*s*., and the expenses were 14,166*l*. 16*s*. 8*d*.; the income tax, which is a charge we are bound to pay, and which I suppose none of you grudge, as it represents the income you have received, comes to 723*l*.; the interim dividend paid on the 24th of June amounted to 16.250*l*., leaving a balance to be carried down of 40,946*l*. 8*s*. 7*d*. In addition, there is the balance brought forward from last half year of 30,979*l*. 2*s*. 8*d*., making in the whole 71,925*l*. 11*s*. 3*d*. We have already given you 1¼ per cent. dividend, or 16,250*l*., and we now propose to pay you the balance of 5 per cent. on the year—that is to say, another dividend of 16,250*l*., leaving 50,000*l*. to be carried to the reserve fund, and a balance to carry forward of 5,675*l*. 11*s*. 3*d*. Well, gentlemen, with regard to the sum carried to the reserve fund. I have so often told you my deliberate opinion on that subject that I think it almost unnecessary to restate it. We pay you a dividend, and we have always paid you a dividend of 5 per cent. on your capital. Well, I have been met with the assertion that 5 per cent. is a small dividend on capital in such a risky concern as this [hear, hear, and "No"]. Well, I admit it—as I have said before—I admit the validity of that observation if we expended our whole net earnings in paying that 5 per cent., but we do no such thing. The way in which we dispose of the balance of our net earnings, after paying you 5 per cent., is in accumulating a reserve fund, which will render that 5 per cent. perpetual. And if you can get 5 per cent. in perpetuity for your money, I do not think anyone will consider it a very bad investment [hear, hear]. Gentlemen, the further sum of 5,675*l*. 11*s*. 3*d*. has been carried forward to next half year. That may seem rather a large sum to carry forward, but there are one or two considerations which I wish to mention which I think you will see justify us in doing so. In the first place, I have told you that, at any moment we may be called on to renew the shore end of the cable at Lisbon. A similar accident to that to which I have alluded may occur again, and we like to retain in our hands sufficient to cover that. Well, gentlemen, there is another matter which I have before now had occasion to allude to here, and that is our relations with the Western and Brazilian Company. Upon the question of our right to suspend the payment of thirds under the agreement with that company there is a difference of opinion between us and the Western and Brazilian Board. We are engaged in a correspondence about that question, but I may tell you that we have not paid the thirds to them since February last, and they have been carried into the accounts of this company. I need not remind you of the uncertainty of the law. The question of the construction of the document, the agreement between us and the Western and Brazilian Company, is a matter for the lawyers, and we therefore have thought it wise, in the event of the matter being decided against us, to retain as a balance from this half year sufficient to pay the Western and Brazilian Company their thirds if they should be entitled to the money. That is the reason for carrying forward so much. The thirds amount to between 3,000*l*. and 4,000*l*. We suspended this payment in February. I confess that, as far as my own individual opinion goes, I think that, after providing for the expenses of the Company, and what the directors consider fair and right to place to the reserve fund, the shareholders ought to be entitled to all the rest of the earnings, and we would not carry forward so much were it not for the possibility of having to meet these two payments. I do not think I have anything further to trouble you with at present, and I will, therefore, conclude by moving the resolution I have already submitted.

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Sir James Anderson: I beg to second that.

Mr. Chalmers thought the amount of the thirds should not have been taken into revenue, but should have been carried to a separate account, pending a settlement of the question at issue.

Other shareholders having addressed the meeting,

The Chairman, in reply, said they had practically done so by carrying forward the balance, but he thought the observation was a very proper one. He might tell them that they had been advised most distinctly that they had a right to suspend the payment, and, therefore, it was under those circumstances that it was carried into revenue in the ordinary way. As to it appearing in their accounts, it had never done so, because payment to the Western Company was the result of taking the two accounts. Each company received moneys as agents of the other, this with the exchange of thirds is compared and the balance paid. He thought it might be well he should explain the nature of this transaction. When the two companies were started an agreement was entered into for a division between them of the gross traffic. Each was to pay one-third of its gross receipts to the other under certain stipulations. The Western Company having made default in the observance of these stipulations, this Company had, therefore, notified to them that they meant to pay them the thirds no further. As to the amount to be put to the reserve fund in the future, he would remind them that the capital of the Company was 1,300,000*l.*, and they had a reserve fund at present of only about 200,000*l.* He confessed that, so long as they could pay a 5 per cent. dividend, his desire would be to put as large a sum as possible to the fund in order to fortify the position of the Company.

The resolution was then carried unanimously, after which

The Chairman moved, and Mr. William Henry Clark, a director, seconded, the re-election of Mr. J. C. de Andrade Pinto, one of the retiring directors. The Chairman said that Mr. Pinto resided in Brazil, and was of the greatest service to them in transacting the Company's business with the Brazilian Government.

The resolution was unanimously carried.

The Chairman then moved, and Mr. Frederick Youle, a director, seconded, the re-election of Mr. C. F. dos Santos Silva, who represents the Company at Lisbon, and was, the chairman stated, a very useful member of the Board.

Dr. Trewhella, who said he ought, perhaps, to have spoken before the first resolution was passed, said he regarded the management expenses as excessive, and he thought that the number of directors was unnecessarily large. The total expenses of management were 6,750*l.* a year, and he thought that the whole affair could and ought to be managed for about half this sum.

The Chairman assured the meeting that neither he nor his colleagues objected to the fullest criticism. He could only say, in reply, that he belonged to some other similar companies, and, if they compared the expenditure of these companies with that of this Company, they would find that the balance would not be against this Company. He had no doubt that the office of Prime Minister might be filled for less than it is, but, though opposed to Lord Beaconsfield in politics, he doubted whether the work would be so well done; and it just came to that. The directors' remuneration was settled by the articles of association, and it would, therefore, make no difference to the shareholders whether there were fewer or more directors. The remuneration of the directors was fixed at 2,500*l.* a year, which was about 1¾ per cent. on the annual receipts of the company, and more than this was paid in London for managing similar concerns. They would continue to do their utmost to keep down expenses, but they could do no more.

The resolution electing Mr. Silva was passed.

A Shareholder also pointed out that the item of the directors' remuneration must have been known to the shareholders when they took their shares, for it was mentioned in the original agreement. He cordially approved the policy of increasing the reserve fund.

Mr. Newton thought that some of the directors in these companies were worth all they received, but considered that there were others who merely diluted the fees, and whose services could therefore be dispensed with. He thought the directors might relinquish 500*l.* a year of their fees till the shareholders received 6 per cent. dividend.

A Shareholder said this amount of dividend could be paid at once by reducing the sum set aside to reserve.

Another Shareholder urged the importance of the Company having at once a supplemental cable.

The Chairman, in reply, said they were putting by money for a second cable. The existing cable was quite sufficient for the purposes of their present traffic. Their policy was to accumulate as rapidly as possible the money to duplicate their cable, but not to lay it out till the necessity arose. It might then be expected to last longer, for if they laid it now it would at once become exposed, and unnecessarily, to the deterioration which a cable suffered from the day it was laid.

Messrs. Henry Dever and John Gane were afterwards re-elected the auditors of the company.

Dr. Trewhella then moved a very cordial vote of thanks to the noble chairman and his colleagues for their attention to the business of the Company. The chairman, he said, was always ready to answer the shareholders' questions, even though they were hypercritical or adverse; and they reposed confidence in the integrity and ability of the directors.

The motion was seconded and carried unanimously.

The Chairman, in reply, very sincerely thanked them for the compliment. The directors deprecated no remarks which were made on their conduct—indeed, the object of calling the shareholders together was to hear what they had to say as to the mode in which the business had been conducted.

The proceedings then terminated.

THE EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY (LIMITED).

Abstract of the Report of the Directors to be submitted to the Tenth Ordinary General Meeting, on Wednesday, November 6th, 1878:—

"The gross earnings of the Company for the half year have amounted to 135,482*l.* The working expenses—cost of repairs and maintenance of cables, new land lines and instruments for the establishment of duplex working on the Madras-Penang cable, payment of income tax, interest on debentures, &c.—amount to 61,222*l.*, leaving a balance of profit for the half year of 74,260*l.* 13*s.* Two interim dividends of 1¼ per cent. each, amounting to 49,937*l.* 10*s.*, have been distributed, leaving the sum of 24,323*l.* 3*s.* to be carried forward to the next half year. The new repairing steamer, *Sherard Osborn*, which at the last general meeting was reported to be in course of construction, has been completed, and has arrived at her station. The Telegraphic Conference referred to in the last report was held at Melbourne in May last, when the question of duplicating the Australian cable was fully discussed, the result being that the Governments of Victoria and New South Wales were empowered to enter into an agreement with the Company for a second cable between Singapore and Australia for an annual subsidy of 32,400*l.*, payable for twenty years. Negotiations have since been carried on with the representatives of the Governments, which, the directors have the satisfaction of stating, have resulted in an agreement on the above basis, the terms of which will be submitted for confirmation to the Extraordinary General Meeting, to be held at the conclusion of the Ordinary General Meeting, together with resolutions empowering the directors to carry the same into effect. The importance of this duplication as a protection of the Company's traffic will, it is believed, be apparent to the shareholders. The capital required, together with the additional amount necessary for replacing capital expended upon repairing ships, and for the general purposes of the Company, the whole not exceeding 660,000*l.*, the directors propose to raise by the issue of debentures redeemable within twenty years."

RECENT PATENT.

759. Telegraph Cables, *F. Lambert.—Dated 23rd February*, 1878. 6*d.*

Telegraph cables are coated with mineral wool, slag wool, or silicate cotton, with a suitable agglutinating material, such as pitch, tar, india rubber, or other substance of a sufficiently cohesive nature, and capable of resisting the action of moisture.

TRAFFIC RECEIPTS FOR SEPTEMBER, 1878.

Companies.	September, 1878.	September, 1877.	Increase.	Decrease.
Anglo-American Telegraph Company	44,310	43,230	80	—
Brazilian Submarine Company	10,463	9,357	1,106	—
Cuba Submarine Company	2,600	2,466	134	—
Direct Spanish Telegraph Company	1,048	812	236	—
Direct United States Telegraph Company	14,770	15,940	—	1,170
Eastern Extension Telegraph Company	22,151	22,113	38	—
Eastern Telegraph Company	£38,169	£35,440	£2,729	—
Great Northern Telegraph Company	15,778	18,445	—	2,667
Submarine Telegraph Company	9,660	10,029	—	1,369
Western and Brazilian Telegraph Company	—	9,504	—	—
West Coast of America Telegraph Company.	2,200	1,625	575	—
West India Telegraph Company	3,792	3,800	—	8

TELEGRAPH SHARE LIST.

Companies.	Closing Prices Oct. 30.		Business Done Week Ending Oct. 30. Highest.	Lowest.
Anglo-American	58,	½	58½	57½
Do. Preferred	84½,	5½	87	85½
Do. Deferred	32,	½	33	32½
Brazilian	6 9-16,	11-16	6¾	6 9-16
Cuba	7½,	8	8	7¾
Do. Ten per Cent. Preference	15½,	½	15¾	15½
Direct Spanish	2,	½	—	—
Do. Ten per Cent. Preference	9¾,	10¼	9 13-16	9 13-16
Direct United States	12¼,	¾	12½	12¼
Eastern	6⅞,	7⅛	7⅛	6⅞
Do. Six per Cent. Debenture	104,	6	—	—
Do. Five per Cent. do.	99,	101	100	100
Do. Six per Cent. Preference	10¾,	11	11	10¾
Eastern Extension	6⅞,	7⅛	7⅛	6⅞
Do. Six per Cent. Debenture	106,	9	—	—
German Union	7½,	8	—	—
Globe Telegraph and Trust	4 13-16,	15-16	5	4¾
Do. Six per Cent. Preference	10¼,	¾	10½	10¼
Great Northern	7¾,	8	7⅞	7¾
Indo-European	19,	20	—	—
Mediterranean Extension	2½,	3	—	—
Do. Eight per Cent. Preference	9,	½	—	—
Reuter's	9½,	10½	10	10
Submarine	215,	20	—	—
West India and Panama	2,	¼	2 1-16	1 15-16
Do. Six per Cent. Preference	8,	½	8½	½
Western and Brazilian	2½,	½	—	—
West. Union Seven per Cent. 1st Mortgage	110,	15	—	—
Do. Six per Cent. Sterling	100,	102	—	—

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NOTES.

Electricity and Lightning.—Dr. Wall, about the year 1670, first observed the existence of electric light, and suggested the resemblance between electricity and lightning.

Direct Spanish Telegraph Company, Limited.—The traffic receipts for the month of October, 1878, amounted to 1,106*l.* 15*s.* 1*d.*, against 914*l.* 2*s.* 6*d.* corrected receipts in the corresponding period of last year.

The Eastern Telegraph Company, Limited. —The Eastern Telegraph Company's traffic receipts for the month of October, 1878, amounted to 41,678*l.*, and to 37,402*l.* in the corresponding period of 1877.

Great Northern Telegraph Company.—The receipts in October, 1878, were 19,737*l.*; the total receipts from 1st January to 31st October, 1878, were 172,092*l.*, and, in the corresponding months of 1877, 173,212*l.*; in 1876, 177,785*l.*

The Electric Light at Cork.—A correspondent writes to point out that the statement which we reproduced in our last issue, relative to a proposal for lighting Cork Town and Harbour, is correctly applicable only to Queenstown Harbour.

Great Northern Telegraph Company.—The Company's cable between Shanghai and Amoy has been repaired, and the lines to Hong Kong, Amoy, Shanghai, Nagasaki, and all stations in Japan are, therefore, now again in perfect working order.

Direct United States Cable Company, Limited.—An interim dividend is announced of 5*s.* per share, being at the rate of 5 per cent. per annum, for the quarter ending 30th September. The dividend is payable on and after the 16th inst.

The Telephone.—A circular has been issued by the Telephone Company (Limited), giving notice that the company will require from all persons using the instruments the annual payment of 2*l.* per telephone; the first year to be paid in advance.

The Electric Light.—Mr. Councillor Lewis has given notice that at the meeting of the Liverpool Town Council next Saturday he will move a resolution in favour of making arrangements for lighting some of the lamps in front and within the enclosure of St. George's Hall with the electric light, for such a period as may be deemed expedient for experimental purposes.

Society of Arts.—The 125th session of the Society of Arts commences on the 20th inst. with an address from the chairman of the council, Lord Alfred S. Churchill. Among other papers, we notice that on December 4 Mr. Shoolbred is to read one on "Electric Lighting;" and that Mr. W. H. Preece is to give the third course of Cantor lectures, beginning in April, 1879, on "Recent Advances in Telegraphy."

The Society of Telegraph Engineers.—The first meeting this season of the society takes place on Wednesday, the 13th inst., at 8 p.m, when Mr. Andrew Jamieson, C.E., honorary secretary of the Society, for Malta and the Mediterranean, will read a paper on "Cable Grappling and Cable Lifting." This is the first paper on the subject that has yet been read, and those interested in the matter will do well to attend the meeting in question.

Lighting Houses by Electricity.—Professor Meinecke, of Halle, in 1836, proposed to light houses and streets by means of the electric spark. He thought that the system would supersede gas, and give a better light and be more economical. His plan was to construct luminous tubes, having at intervals metallic plates, on which were formed, by means of a machine, a rapid succession of electric sparks. Professor Meinecke obtained from a two-foot machine a constant light in his room resembling a bright moonlight. By confining the sparks in a tube of hydrogen, the professor thought it would be possible to obtain a similar result on a large scale.

Electrolytic Method of Estimating Mercury.—The author (F. W. Clarke) proposes to determine mercury as follows:—The solution of the mercury compound is poured into a platinum dish, and slightly acidified with sulphuric acid; the dish is connected with the zinc end of a dichromate battery of six cells, whilst to the carbon end is attached a piece of platinum foil, which dips in the solution. At first, mercurious chloride separates out, which is finally changed to metal; in the course of an hour, all the mercury is precipitated. The metal thus obtained is washed carefully with acidified water, then with pure water, alcohol, and ether, and dried over sulphuric acid and weighed. Two determinations in mercuric chloride gave 73·76 per cent., and 73·85 per cent. mercury, the calculated percentage being 73·8 per cent. The method has been tried with other salts than the chloride, and is found to act in the case of insoluble basic salts.—*Chem. Soc. Journal.*

Edison and His Light.—The *Scientific American* publishes what seems to be authentic information regarding this so-called discovery. To those, however, who could read, we gave the same information in a short leading article and a note a fortnight ago. If the article we reprint from our contemporary really describes the work of Edison, we can only say to our *confrères* on this side the Atlantic—wait, till the words you would write are less forcible and condemnatory. It is hard, we know, to restrain one's pen, especially when we think of the millions that have been lost, through the excitement, by the depreciation of gas shares. At present, we see no loophole by which the American papers can escape the severest censure. Politicians believe in national partisanship, but, above all things, science should be truthful, and in every shape and form abhor exaggeration. We refrain from saying anything more on this question for the present, in the hope that further information will reach us before our issue next week.

Speedy Manipulation.—The following instance of smart operating is quoted in the *Journal* of the Telegraph Electrical Society, Melbourne. It is one of those things which *may* be quite true, but which it is comforting to have thoroughly well authenticated before giving them implicit credence:—"On Saturday last, says the *Otago Times* of the 4th April, Mr. L. R. Jaggar and Mr. B. H. Keys, two operators connected with the Dunedin Telegraph Office, had a trial of speed, the former operating, the latter receiving. Mr. Jaggar telegraphed for half an hour a political speech, and, when time was called, the result for the thirty minutes was 1,252 words, or within a fraction of forty-two words per minute. This was received by Mr. Keys, and written in a clear, round, legible hand. This shows the speed which, by practice, may be accomplished. To write for half an hour at the rate of forty-two words per minute is no mean feat, but to keep up that speed at the telegraph key is wonderful. Not only has every word to be clearly spelt, but each has to be formed by a series of touches to form the component parts thereof. The long message was taken off by Mr. Keys with only two

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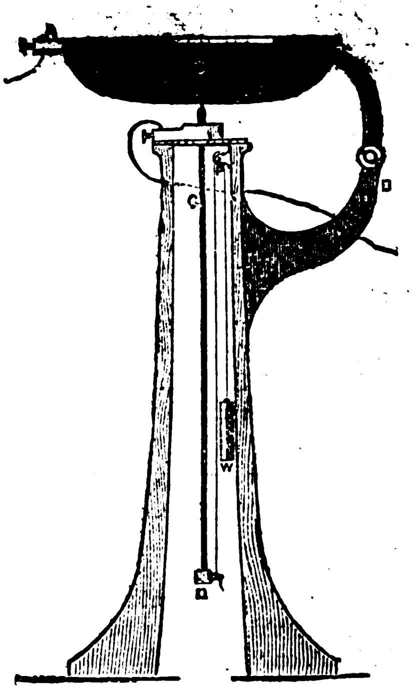
'breaks' or interruptions. Mr. Jaggar for a shorter time accomplished a greater speed than this, sending on one occasion an ordinary message of 126 words in scarcely two minutes. We understand the test above alluded to arose out of a bet, and the operator, who was then crowned with success, has since been crowned with a new hat."

The Electric Light at Woolwich.—The Government authorities are trying the adaptability of the electric light for the illumination of large workshops by some experiments at the Royal Arsenal, Woolwich. A new carpenters' shop has recently been erected in the Royal Laboratory yard, and, pending the provision of gas fittings, a single electric lamp has been hung from the roof, and by its light men have been making shot-boxes for a week past. It is found that the lamp furnishes a good light to work by for fifty feet in every direction, and that, for workshops where the roof is high and the space unobstructed, the electric light is suitable and pleasant. The cost of the one lamp has been 8d. per hour, and it answers the same purpose as forty or fifty gas-jets; but the steam power for generating the electricity is supplied without charge from the shafting in the main factory adjacent, and nothing is calculated for wear and tear of apparatus. The light, though always brilliant, is somewhat intermittent, consequent upon the ever varying pressure upon the machinery, which drives more than five hundred lathes, and the small limit between the minimum and maximum number of revolutions required for the electric light is thought to render the employment of standing machinery in most cases unsuitable. The apparatus has been tried in the Shell Factory of the Royal Arsenal, and the light was popular with the workmen; but, probably from inexperience, the result was not quite successful. It is proposed to place a light in the outer yard of the Laboratory, in front of the model room, and it is also contemplated to light the main factory in the same manner; but the net-work of machinery and bands, and the low pitch of the roof, are unfavourable to the experiment.

Electric Light.—In recent years most important investigations have been been made by Professor Graham Bell and Mr. Edison, which have led to the construction of the telephone, microphone, and other instruments for conveying the human voice and other sounds to great distances, and which may hereafter prove of the greatest importance. Although these inventions are still in their infancy, and may require time before they come to much practical utility, they in the meantime mark a great advance in electrical knowledge. The further discoveries of Gramme in France, and Siemens in England, of means for the easy and continuous production (or, as we might say, the manufacture) of electricity, and its application to lighting and other purposes, have caused the electric light to occupy at the present time a very prominent position among the subjects of interest to scientific men; and, should the very recent alleged discoveries of Mr. Edison prove correct, by which the supply of electricity can be split up into a thousand or ten thousand different lights, and in this way be conveyed to our dwellings to take the place of gas, it may create a change the end of which we can hardly contemplate. For, in addition to the proposed extinction of gas, electricity so easily and successfully produced by the Gramme or Siemens machine may come to be applied in the arts and manufactures in various ways hitherto not known. It may in many cases supersede coal as a motive power, or be applied in metallurgy, and thus affect large commercial interests. It must, however, be borne in mind that up to the present time it has not been possible to give any reliable information as to the cost of supplying electricity on the large scale from a dynamo-electric machine keeping up a continuous daily and nightly supply, whereas it is well-known that gas can be supplied in this country at a a very low price, owing to the fact of the by-products—consisting of tar, coke, and ammoniacal salts—finding a ready market at prices which, as a rule, may be said to nearly recoup the first cost of the coals used. In the meantime, while waiting for further information, these discoveries are well worthy of our thoughtful attention, and I trust that some of our members may favour the Society with papers on these subjects.—From the inaugural address of R. C. Clapham, F.C.S., to the Newcastle Chemical Society.

The Werdermann Electric Light.—On Saturday, Nov. 1, a goodly number of spectators witnessed a series of experiments with a new light, devised by M. Werdermann, the inventor of the *bougie* known as Jablochkoff's. The experiments were carried out at the workshops of the British Telegraph Manufactory, in Euston-road, and were decidedly successful. It is doubtful, however, whether M. Werdermann is the first to devise this system, but, be that as it may, it is worthy of a fair trial. The electric current was obtained from a plating machine of the Gramme type, driven by a six-horse power engine, but it was stated that the engine was far more powerful than was actually required. The rough statement made as to the photometric value of the lights is given for what it worth, as we have, of course, been unable to test it ourselves. When two lights were in circuit, each was stated to be equal to 320 sperm candles. With ten lights in circuit the light per lamp was greatly reduced, but each light was very steady and brilliant. The arrangement will easily be understood from the accompanying diagram, for which we are indebted



to our contemporary, the *Engineer*. C is a block of carbon which is connected to the negative pole, the positive pole being connected to the carbon rod *c* some three or four millimetres in diameter, and of any desirable length. The carbon rod is kept in contact with the block by means of a weight W passing over a pulley. The whole arrangement is exceedingly simple. The method of dividing the lights is that known and used to so great an extent in every branch of electricity, viz., "the multiple-arc system."

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ON THE STUDY OF ELECTRICITY AS A PROFESSIONAL PURSUIT.

BY THOMAS T. P. BRUCE WARREN.

(CONTINUED FROM PAGE 257.)

Insurance firms would do an act of great benefit to themselves and to the sea-going community if they would only place some restriction on the illuminating materials allowed to be used on board ship. Sea captains, as a rule, are not men who are likely to trouble themselves with the flashing point, &c., of petroleum, and whilst, perhaps, an oil may be safe in this country with the ordinary ranges of temperature, we must be cautious in accepting the same standard for warmer or tropical climates. Petroleum oil with a flashing point below that which is supplied by the Silber Light Company should never be allowed to be used below deck; it does not burn so well as the lighter oils in the lamps used for testing, but its safety is an enormous recommendation. With the lamps they supply, the heavier oils give an extraordinary illuminating power, which is of great advantage for lighting up cable tanks at night, and for use on deck during the paying out of cables.

If these liquids be used to prevent evaporation from batteries, care should be taken to procure oils having a high boiling point, and free from the lighter and more inflammable oils.

Manganese.—The binoxide or manganic oxide is used in the Leclanché element. The article met with in commerce contains variable proportions of the manganic di-oxide, so that it is necessary to test each purchase, since the value of it depends on the amount of available oxygen it contains as an oxidizer. Another very important fact in connection with this substance, and which is more particularly of interest to the electrician, is that the oxides of manganese, by which we must understand the minerals sold as manganese, have great differences in their conducting power for electricity. The most reliable method in use for testing manganese is that known as Bunsen's method. The principle of the test depends upon the fact that chlorine is capable of displacing iodine in its combination with potassium, so that by measuring the iodine thus set free we ascertain how much chlorine has been liberated. Now, when hydrochloric acid is boiled with these oxides, we obtain free chlorine from the decomposition of the acid just in proportion as the sample contains more or less oxygen. One gramme of pure binoxide will yield 0·816 grammes of chlorine, so that, if we test a sample giving 0·408 grammes chlorine, we should say that the sample contained 50 per cent. binoxide of manganese. It must not be taken for granted that it contains actually half its weight of the binoxide; there are other oxides of manganese which are capable of decomposing hydrochloric acid with the liberation of free chlorine; but, as the amount of chlorine is greater with the higher oxides than those compounds containing either the pure oxides in a lower degree of oxidation or mixture of the several oxides, the nearer we approach the value for pure binoxide the more certain we are that the other oxides, if present, must not be large. A fair sample should yield from 85 to 87 per cent. of chlorine, equivalent to that from the pure binoxide, in which case we say that the sample contains 85 per cent. or 87 per cent. binoxide.

All the oxides of manganese yield chloride, except the first or protoxide, when boiled with hydrochloric acid. Thus:—

Mn^2O^3 = 1 eq. O = 2 eq. cl.
Mn^3O^4 = 1 „ O = 2 „ cl.
MnO^2 = 1 „ O = 2 „ cl.
MnO^3 = 2 „ O = 4 „ cl.
Mn^2O^7 = 5 „ O = 10 „ cl.

Expressed in terms of binoxide, we should say that the samples represent theoretically per gramme:—

Mn^2O^3 =	·4494 grammes cl.	=	55·07 per cent.	MnO^2.
Mn^3O^4 =	·3101 „	=	38·00 „	MnO^2.
$Mn\,O^2$ =	·8161 „	=	100·00 „	MnO^2.
$Mn\,O^3$ =	1·3796 „	=	169·12 „	MnO^2.
Mn^2O^7 =	1·4912 „	=	182·72 „	MnO^2.

It will be thus seen that the oxides are all reduced to the state of protoxide MnO.

The two last are called manganic and permanganic acid. The minerals met with in commerce as manganese consist either of mixtures of the first two or three oxides, or of the separate oxides with iron, silica, &c.

MnO^2 occurs principally in the mineral pyrolusite.

Mn^3O^4 is met with principally in Hausmannite.

Braunite, manganite, psilomelane, are the other principal ores which contain variable proportions of the other oxides, as carbonates, or with sulphur, phosphorus, &c.

There are several methods of testing manganese. Objection has been raised to the method proposed by Fresenius and Will, which consists in determining the amount of oxalic acid which a given weight of the sample will convert into carbonic acid. Samples tested in this way will show a higher per centage of MnO^2 than when examined by the chlorimetric method, since a little chlorine is consumed in converting the iron contained in the mineral into perchlorides, &c.

This objection is simply raised on account of the large quantities of ferrous iron now found in the commercial ores of manganese. The estimation by means of iron and hydrochloric acid is equally suited for the use of the electrician, and may be worth a special treatment at some future time.

About 200 grammes of the ore should be very finely powdered in an iron mortar. It is easier to obtain a fair average sample by taking this or a larger quantity than by simply working on the weight required for the analysis.

The powdered ore is well mixed together, and a few grammes carefully heated to 248° F., so as to ascertain the loss due to moisture, which will vary from 4 to 10 per cent.

As manganese thus dried absorbs water from the air, it should be allowed to cool in a closed vessel. An iron spoon or ladle will answer for this purpose. I prefer a glazed porcelain capsule for drying, and allow it to cool in a desiccator, over sulphuric acid.

Half a gramme of this powder is placed in a flask capable of holding about 150 c.c. water, and a few pieces of magnesite or native carbonate of magnesia are added; 30 or 40 c.c. of strong hydrocloric acid is poured in.

A spirit lamp is held under the flask, so as to heat the acid and generate the chlorine. As soon as this has commenced the lamp may be moved to and fro, so as to allow the chlorine to pass over slowly, to ensure its perfect absorption. Too rapid an evolution may lead to a loss, either of chlorine or the ejection of the liquid in the absorption tubes.

The object of the magnesite is to prevent the liquid in the absorption tubes being drawn over into the flask when the lamp is removed. A current of carbonic acid is thus kept up, and which also serves the purpose of expelling the chlorine from the flask.

The connections are generally made with caoutchouc, taking care, at the same time, that the glass tubes are close to each other, so that the chlorine does not come in contact with the India rubber more than can be avoided. I prefer using common corks, soaked in a mixture of paraffin wax and rosin where practicable, since both iodine and chlorine are both taken up by caoutchouc.

The apparatus should have as few joints as possible.

I give here the treatment, which I find very convenient, of the liquid when removed from the absorption tubes together with the washings.

The whole liquid is made up to 200 c.c., and, if any portion of the iodine set free has not redissolved, a little iodide of potassium should be added before making up the 200 c.c.; 100 c.c. is measured off, and the solution of hyposulphite of soda run in until the liquid has a distinct yellow colour. Starch solution is now added, and the hyposulphite added, drop by drop, until the last drop causes the blue colour to entirely disappear.

The next portion of the liquid is treated in the same way, the burette being refilled with the hyposulphite solution; the number of c.c. required should be the same in each case.

It is possible, however, that in the first trial the hyposulphite solution may have been added in excess, and we have then to work backwards, as it were, by adding iodine solution until the blue tint just appears. The iodine solution is added from a similar burette.

This method enables the work to be done entirely with the iodine solution from the absorption tubes, without dealing with a standardised solution of iodine.

Suppose we added to the first 100 c.c. iodine solution 48 c.c. of hyposulphite, which was too much to complete the ending of the test. We drop into the mixture from a burette, cautiously, a little of the iodine solution until a blue tint is just visible. If it has required 5 c.c. to effect this, we know that 105 c.c. iodine has required 48 c.c. hyposulphite. We then add the whole of the iodine solution, and run in the hyposulphite carefully, so as not to overstep the exact mark. If 105 c.c. iodine takes 25 c.c. hyposulphite, the whole 200 c.c. will require approximately 91·4 c.c. In this way the titration of the iodine may be very neatly and rapidly effected. If the starch liquid is added at first to the strong solution of iodine, the starch is precipitated together with the iodine in lumps, which are not so readily acted upon by the hyposulphite. This does not happen when the solution has been cleared of a little of its iodine before adding the starch.

The hyposulphite solution should be examined from time to time with a weighed quantity of perfectly pure iodine, as it will not keep constant for any great length of time. ·5 grm. of pure and dry iodine is dissolved in a solution of iodide potassium, and the amount of hyposulphite required determined as above.

There is not much advantage gained in going to the trouble of

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making the hyposulphite solution so that any required measure of it corresponds to a definite quantity of iodine, unless for matters of research, or some special purposes; for, since it is liable to alteration, we are bound to determine the relation between it and some known quantity of iodine. If it has been prepared so that 1 c.c. corresponds to ·0127 grm. iodine, and we have required to use—say, exactly 187·4 c.c. of the hyposulphite solution for one gramme of the ore, then $187{\cdot}4 \times {\cdot}0127 = 2{\cdot}380$ grm. iodine set free. Then to ascertain the corresponding amount of chlorine:—

Eq. of Iodine : Eq. of Chl. :: Iodine found : Chl. corresponding.
126 : 35·5 :: 2·380 : 0·6705

Now, 1 gramme MnO_2 yields 0·82 gramme chlorine, then ·82 : ·6705 :: 1 : 81·77, the amount of MnO_2 found. We can now simplify the calculation for future operations, by calculating how much hyposulphite solution will correspond exactly to a known weight of pure $(MnO_2)^2$. ·6705 : ·82 :: 187·4 c.c. : 229·2 c.c., then 229·2 : the no. of c.c. required :: 100 : the value of the sample. The solution of the hyposulphite soda should contain 24·8 grammes of the perfectly dry and pure salt per litre, then 1 c.c. will correspond to ·0127 grm. iodine = ·00355 chlorine. It may be necessary to point out that it is not easy to procure this salt sufficiently pure to make the solution of the exact strength without very careful adjustment.

Manganese ores are obtained principally from Devon, Spain, Portugal, Germany (Nassau, Darmstadt, Thuringia, and Saxony), Turkey, New Zealand, Virginia (U.S.A.), San Francisco, and Nova Scotia; the shipments being made at the alkali ports in this country as the Mersey, Tyne, and Clyde. Pyrolusite is used largely in the manufacture of several descriptions of glass to destroy the green colour due to the presence of ferrous iron in the materials, which, by the addition of a small quantity of binoxide manganese becomes peroxidized. The excess of manganese will give a slight violet tinge to the glass, which is heightened after exposure to the air for a short time.*

It would be interesting to ascertain whether the electrical properties of glass are affected by manganese, or whether glass slightly tinted by the presence of ferrous oxide is a better or worse insulator than the same glass rendered colourless by means of manganese.

The ore best suited for electrical work is that known as crystalline, which is obtained principally from a mine in Nova Scotia, and a few small mines in Thuringia and Saxony. These ores range from 75 per cent. to 83 per cent. of binoxide, some of the Nova Scotia mines yield manganese ores reaching as high as 98 per cent. This occurs in the "needle crystals," which are so soft as to break up easily between the fingers. Its special use is for the best kinds of plate glass; it is too brittle for use in batteries. A semi-crystalline mineral occurs in a mine at Upton Pyne, near Exeter, which yields 95 per cent., but its formation is not well suited for use in batteries, being too soft in texture to admit of being broken up to the sizes or granules employed for batteries.

Consequently, the harder varieties are more commonly employed which admit of being granulated without necessitating any serious loss from being reduced to powder.

In general, the manganese ores are richer in binoxides the nearer they occur to the surface of the workings, and become poorer the lower the mines are worked.

The solution of iodide potassium may be made by dissolving 33·2 grammes in a litre of distilled water. About 80 c.c. of this solution will then be sufficient for half a gramme of manganese ore.

Several precautions are necessary with respect to the solutions and the purity of the several substances to be dissolved. Pure iodide of potassium, free from iodate, is essential, and its solution should be made as required. The pure hyposulphite of soda may be roughly powdered and dried, without losing its water of crystallisation, which may be done by pressing between blotting paper.

The starch solution is made from the best white starch, and must be quite thin and well cooled before using.

The absorption tubes are placed in a large beaker filled with water, so as to keep the whole perfectly cool. The safest plan is to titrate the solution an hour or so after the operation, and, if great exactness is required, to use a little fresh iodide potassium solution in another tube, so as to make quite certain that all the chlorine which is capable of being given off is collected.

This will be at once seen, as the solution is rendered slightly yellow, with a very small quantity of chlorine.

The estimation by means of iron consists in peroxidising a given weight of ferrous salt, which is in excess, by boiling the powdered ore with sulphuric acid, and titrating the solution with permanganate of potash, or bichromate of potash, for the amount of iron left in the ferrous state. This method is largely used in commercial analysis.

Chloride of Ammonium or Sal Ammoniac.—This salt is obtained by passing ammonia into a vessel containing hydrochloric acid, the source of ammonia being the ammoniacal liquor from gas works. It occurs in commerce very pure, containing but very slight traces of impurities, principally iron and carbon, as well as the impurities usually met with in commercial muriatic acid. This is the principal source of the iron. It yields also traces of cyanogen compounds and sulphuric acid.

Its loss at 212° F. should be very slight when a weighed quantity of it in the form of a powder is kept for twenty-four hours at this temperature. It should not yield more than a slight turbidity with a baryta salt in solution. A current of sulphuretted hydrogen passed through the acidified solution should produce no change, showing the absence of lead, arsenic, &c.

The addition of a little nitric acid to the solution of ferrocyanide of potassium poured in should produce a slight bluish-yellow tint only due to iron.

The estimation of ammonia and chlorine may be required in examining a battery residue, and, as the ammonia may, by oxidation, be converted into nitric acid, the electrician should be able to ascertain whether such charges are produced.

The contents of a cell, or a portion of it, should be poured into a small flask, provided with a bent tube passing into another closed flask or receiver, and containing muriatic acid. A funnel tube is fitted to the first flask, to contain either caustic, soda, or potash, which is allowed to flow slowly in so to expel the ammonia; a gentle heat is necessary. The liberated ammonia is absorbed by the acid. When the operation is ended the solution in the receiver is evaporated to thorough dryness on a water bath, and the residuum weighed. This is the simplest method.

The chlorine is determined readily by means of a standard *neutral* solution of nitrate of silver, prepared by dissolving 17 grammes of the pure fused salt and making up to 1 litre; 1 c.c. will then represent 0·0108 metallic silver = ·017 nitrate silver, and correspond to ·00355 chlorine.

A few drops of a saturated solution of chromate of potash are added to the solution to be examined, which must be perfectly free from acid. The silver solution is run in until all the chlorine is taken up, which is known by the appearance of a red colour when the reaction is ended.

Care must be taken that the chromate of potash is free from chlorine, and, as the chromate of silver is easily soluble in free acid, that the solutions are perfectly neutral. The first appearance of a red spot shows that the chlorine is all taken up by the silver, and that the silver is now being converted into chromate.

The converse of this, in having a standardized solution of chloride of sodium, is the easiest way of estimating silver, as in platinum silver, alloy, &c.

This alloy may be easily analysed by boiling the finely-drawn wire, or attenuated sheet, in strong sulphuric acid, diluted with twice its volume of water. The silver dissolves out, leaving the platinum in a divided state.

Sulphate of silver is easily soluble in boiling water; it may be precipitated and weighed as chloride, or the solution rendered perfectly neutral by evaporating to dryness, redissolving in water, and titrating with a standard solution of chloride of sodium.

[TO BE CONTINUED.]

LITERATURE.

ELECTRIC LIGHTING.

Electric Lighting. A Practical Treatise. By Hippolyte Fontaine. Translated from the French by Paget Higgs, LL.D., Assoc. Inst. C.E. E. and F. N. Spon.

This is not only the best, but it is a book without a rival in the literature of electric lighting, so far as England is concerned. It is a singular statement, and yet it seems to contain a vast amount of truth—that we, as a rule, follow, and do not lead. A careful inquiry into many branches of industry shows that for a long time England held aloof from participation in them, but when at length her workers are roused it is to compete for, and frequently to obtain, the first place in the race. Will this be the case with electric lighting? America, France, and Germany, have thrown their energies into the question, while England has done comparatively nothing. The daily papers teem with idiotic communications on the subject of electric lighting, which make them the laughing stock of scientific electricians. We can only

* I am indebted to Messrs. McQueen and Sons, of Old Jewry Chambers, E.C., for the sources and description of these ores.

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suggest to some of the gentlemen who are so eager to gain one day's fame, that they should forego the pleasure and devote the day to the study of the subject. This work of Fontaine's, admirably translated, will be found to contain a vast amount of trustworthy information. The author's object will be seen from his preface, where he says:—"We ignore surprises that the future may reserve for us; but our knowledge of the subject leads us to affirm that the *rôle* of electricity is far from its full development, especially from the point of view of the transformation of motion into light. It is not of so much importance to know what will be as to know what is. And it is to this end that we present a study of the elements of electric lighting that have definitely entered the domain of practice, and of the best conditions for its use. Later, as perfections are more nearly attained, we shall put them so much better to profit that we can better appreciate the advantages; it appears to us irrational to neglect the use of what is already good, under the pretext that we shall one day arrive at something more nearly perfect." In his first chapter the author discusses the "voltaic arc," then describes the various electric regulators, which, however, may now be said to be obsolete. These regulators, however ingenious, however successful, must necessarily complicate any large system of electric lighting, and Werdermann has shown by his invention, generally accredited to Jablochkoff, and known as Jablochkoff's candle, that a regulator is unnecessary, as have Harrison, Wallace, and several others, so that, except in laboratories, the days of regulators are numbered. Of far greater importance is the manufacture of carbons, for, although Mr. Edison has taken a "new departure," it may safely be said that Mr. Edison, nor any number of Edisons, will, for a long time to come, displace carbon as the burner.

The following *résumé* of M. Gaudoin's experiments with carbons containing foreign substances is especially interesting (pp. 44-5):—"The following bodies have been introduced into the carbons: 1. Phosphate of lime from bones; 2. Chloride of calcium; 3. Borate of lime; 4. Silicate of lime; 5. Pure precipitated silica; 6. Magnesia; 7. Borate of potash; 8. Phosphate of magnesia; 9. Alumina; 10. Silicate of alumina."

The proportions were calculated in such a manner as to obtain 5 per cent. of oxide after the cooking of the carbons. These were submitted to the action of an electric current, always of the same direction, furnished by a Gramme machine powerful enough to maintain a voltaic arc of ten to fifteen millemetres in length.

The negative carbon being placed at the bottom, M. Gaudoin has observed the following results:—

1st. The complete decomposition of the phosphate of lime under triple influence of electrolytic action, calorific action, and reducing action of the carbon. The reduced calcium goes to the negative carbon, and burns in contact with the air with a reddish flame. The lime and phosphoric acid are diffused into the air, producing abundant fumes. The light, measured by a photometer, is double that which is produced by carbons of the same section cut from the residue of gas retorts.

2nd. Chloride of calcium, borate, and silicate of lime are also decomposed, but the boracic and silicic acids appear to escape by volatilisation from the electric action. These bodies give less light than the phosphate of lime.

3rd. Silica, introduced into the less conducting carbons, melts, and volatilises without being decomposed.

4th. Magnesia, borate, and phosphate of magnesia, are decomposed, the magnesium in vapour goes to the negative carbon, and burns, in contact with the air, with a white flame. The magnesia, boracic and phosphoric acids diffuse into the air in a state of vapour. The increase of light is less considerable than with the lime salts.

5th. Alumina and silicate of alumina are decomposed only with a very strong current, and a very considerable voltaic arc, but under these circumstances the decomposition of the alumina is well manifested, and the alumina, in vapour is seen to go off from the negative pole like a jet of gas, and burn with a blue flame of little lighting power.

The flame and vapour which constantly accompany these electro-chemical lights having appeared to him a great obstacle to their utilisation for illumination, M. Gaudoin has not pushed these experiments further.

For a description of the most important processes for the manufacture of carbons, such as those of Carré, Archereau, and Gaudoin, we must refer our readers to the work itself. We may just remark that the carbons made by these eminent firms render the electric light a possibility. It is necessary to have good carbons as well as good machines. The greater portion of the book is devoted to the consideration of magneto-electric machines, their construction, principles, and application to electric lighting. The Gramme machine is described at considerable length, and a large number of experimental data are given. Of the electric light the author says:—"Experience has shown that working by the naked electric light is not fatiguing to the eyes; after some days using opal globes to temper the light, these were removed at the request of the workmen. The reduction of the light is unnecessary.

It is generally known that the electric light preserves the tints of colours. This property has been utilised with success by several dyers for standardising their colours by night; a single luminous focus of the very smallest dimensions is sufficient in this case.

When the ceilings are at less height than four mètres, the introduction of the electric light becomes more difficult, without however, being absolutely impossible.

Generally, there may be conveniently lighted with a single apparatus 500 square mètres of fitters' shops, lathe-shops, tool shops, modelling rooms, &c.; 250 square mètres in a spinning mill, weaving establishment, printing rooms, &c., and 2,000 square mètres of yard, court-yard, dockyard, quay, and open air works, &c. With these data, it is easy to calculate the cost of introduction anywhere, knowing that a complete apparatus, lamp, machine, conducting wire, transport and mounting, costs about 2,400 francs (100*l.*) in France and its frontier countries.

Manufacturers who pay only 0·30 franc per cubic mètre, and find their establishments sufficiently lighted with twenty gas burners, should not seek a more economical light, unless they work all night without interruption, in which case it would be to their interest to replace ten gas burners by an electric apparatus.

The two questions to be examined are the cost price and the convenience. The second is often neglected, but this is wrong; because, in the majority of cases, it is of the greater importance. We have had occasion to visit a large number of works, factories, and manufactories of all kinds in Europe and in America, and we have seen but few well-lighted establishments; few where a single more intense light would not have given easier superintendence, greater amount of work, and greater security. Fire insurance companies have so important an interest in the introduction of the electric light that several have offered to lower their tariff for all buildings thus lighted."

For an account of the factories in which the light has been tried, and for the cost of the experiments, we must refer to the book itself; suffice it to say that there is no stint of detail. The work should be in the hands of everyone interested in the electric light. We should be glad to see such works as this more popular with English readers. We grumble sometimes that we cannot obtain what we want, and yet when it is placed before us refuse to use it. The publisher, translator, and author, deserve success in their efforts to give reliable information.

ELECTRIC LIGHTING.—VACUUM GLOBES.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Whilst professional inventors are concentrating their attention on the important question of the extent to which the electric current is capable of being divided, may I, as an outsider, be allowed to suggest that the question of the rapid consumption of carbon points might be satisfactorily disposed of by the use of vacuum globes.

My idea is not new in *principle*, but I have not seen it suggested for *application*. Professor Pepper and others have pointed out that carbon points *in vacuo* do not consume nearly as fast as in air, but it does not appear to have occurred to these writers that a lamp might be constructed on the principle of the vacuum tubes of Geissler, which might obviate the necessity of carbons altogether. I have myself ascertained that it is possible to read small print by the light generated by a weak voltaic current in a vacuum tube, therefore it seems to me that a strong current, by whatever means it might be excited, could produce a light which, if used *in vacuo*, would be capable of adaptation to domestic purposes. The advantages to be derived from such a means of illumination are obvious, as, besides the mellowness of the light, its use would be attended with *absolute safety*, for a light which exists *in vacuo* ceases to exist if the vacuum be destroyed by the breaking of the lamp globe; moreover, for the purposes of miners' lamps, the vacuum principle would seem to be specially safe and useful.

Have any of your readers experimented in this direction, either with a dynamo-electric machine or with voltaic batteries?—
Yours faithfully, P. H. Fowell-Watts, S.S.C.J.
West Hackney, 4th November, 1878.

Cuba Submarine Telegraph Company.—The number of messages sent during October by this Company was 2,679 as against 2,608 during the corresponding month in 1877.

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We shall be happy to exchange with the Editors of Scientific journals who receive the first numbers of THE ELECTRICIAN.

Nous serons heureux de faire l'échange avec Messieurs les Rédacteurs des Journaux scientifiques qui recevront les premiers numéros de L'ELECTRICIAN.

Es wird uns ein Vergnügen sein mit den löblichen Redactionen der deutschen und anderen continentalen Journäle und Zeitschriften, denen die ersten Nos. des ELECTRICIAN *zu Händen kommen möchten auszutauschen.*

I Signori Editori di giornali scientifici che riceveranno i primi numeri dell' ELECTRICIAN *ci faranno cosa gradita accettando il cambio che loro offriamo.*

PATENTS AND PATENTEES.

The title of this article suggests volumes of blue-books, thousands of wasted lives, and, to exhaust the subject, a treatise more voluminous than the " Chinese Encyclopædia" recently publishedby the British Museum. This title, without some qualifications, might be misleading. We have no intention of attempting even to treat this great subject, but wish to write a word of warning to the many who think they have discovered something wonderful, and are determined to try and get rich by means of electricity and the electric light. The thousands who have visited Paris have come back with a more or less decided opinion upon the value of the electric light. Mr. Hollingshead has enabled many who have not visited Paris to get an opinion of its merits, and rapidly public opinion has rushed to a conclusion. Hundreds who have dabbled a little in experimental electricity have furbished up their slumbering ideas, and with ideas only have gone to the patent office for a provisional specification. For some months to come we shall be unable to judge of the value of the ideas, but it is within the mark to say that not one-tenth of the patents applied for are worth twopence. The nine-tenths serve only to swell the fees received by the Patent Office. The would-be famous inventor has bought a little experience at the cost of a few pounds, and well for him will it be if he contents himself in future with having ideas and not seeking to patent them. Few —and those few only after years of anxious study—are able to put a value upon a sudden inspiration, and to say whether it is practicable or not. As a rule, a successful experiment in the laboratory needs a good deal of modification before it can be adapted to a larger scale, and many an experiment is successful under circumstances which preclude the general use of the means employed.

In the case of the electric light, it is necessary not only to provide a light, but to provide it cheaply, before it is likely to supersede gas. The patentee does not always keep this in mind, but thinks the great object is to get a lamp or a machine, or to subdivide the light. These, no doubt, are important, but, in fact, present little or no difficulty, except in the matter of cost. Our daily contemporaries, hurried away by an eager desire to get something new, have filled the public mind with a mass of rubbish which all the efforts of all the scientific papers will never remove. We are thus, again, cursed with the curse of ignorance. Take, for example, the so-called subdivision of the electric light. We should be glad to meet with any electrician of repute who would have looked upon it as a problem of any particular difficulty, and yet the public has been brought to look upon this as a problem of surpassing difficulty, and unsolvable, till Mr. Edison appeared upon the scene. Now, we have before us a pile of books, all of which give one solution at least of the problem in question, and one of these solutions is, we observe, adopted by M. Werdermann, and, we believe, also by one or two other patentees. Months ago, when statements were made by friends ignorant of electrical theory, we tried to expound the laws of the "multiple arc," and its uses. The system of dividing the light by this means may have been patented, but we doubt if such a patent can hold good. The method has been discussed over and over again to our knowledge, both in France and in England. We do not intend to indicate this as the best method, but simply one which would immediately suggest itself to the electrician as worthy of trial. Again, the same inventor uses a small rod of carbon in contact with a large mass of the same material. We are not quite sure as to what makes a valid patent, but more than twenty years ago a patent was taken out in which a cylinder of carbon formed the negative and a point the positive. Several modifications are mentioned in the patent, but, whatever be the merits of the invention, and whether new or old, the test will be the cost. Here, again, the warning comes, and we are tempted to ask, have the facts so long accepted as true been proved to be false? Does Joule's law hold good for currents from dynamo-electric machines? Are the mechanical and heating powers of the current proportional to each other? Is the resistance of carbons in contact necessarily less than when they form the electrodes of the arc? The inventors who hurry to the Patent Office during the height of the excitement are hardly in the frame of mind to accept advice, and yet we would strongly urge them to make exhaustive experiments before swelling the list of patents. We are looking at the question as a question of probability, and, without doubt, many are wasting time and money because they do not understand what is required, and are not acquainted with what has already been done. It is far better to write such a letter as appears in another column, and to be told that the idea is not new, that it has been tried and found wanting, that it would be too costly even if all other things could be arranged, than to take out a patent. Inventors may be almost certain that, if they do not open up entirely new ground, the road has been trod pretty often, and, although it is not impossible to find something that has been missed, it is very doubtful whether most of what is gleaned has not already been tried and abandoned.

THE EDISON LIGHT.

We give the following on the authority of the *Scientific American*:—

The announcement that Mr. Edison has discovered a means for dividing the electric current indefinitely, thereby making it possible to use electricity for lighting small areas, has had a marvellous effect in bringing down the value of gas stocks.

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The stock of the Chartered Gas Company of London, for example, has been depreciated in the market between five and ten million dollars, if we may trust a statement made before a recent meeting of the company. At an auction sale of gas stock in this city, October 16, shares of the New York Gaslight Company, that on September 11 brought 91¾, sold for 78½. Shares of the Manhattan Company, that sold for 200½ in September, went for 149½. Whether this enormous falling off in value in six weeks is to be charged entirely to the fear of electric competition does not appear; but evidently the larger part of it is, for a similar decline is noticeable in other places. Is there any sufficient reason for it?

The manufacturers of gas say that there is none; that the electric light is simply a co-ordinate branch of illumination, and not nearly so dangerous a competitor as the petroleum light is. The electric light may answer and be economical for lighting large spaces from a single source; but even that is made doubtful by recent improvements in large gas burners, with which the increase in illuminating power is very much more rapid than the increase in the amount of gas consumed. The use of electricity for lighting rooms of moderate dimensions is declared impractical from the difficulty or impossibility of dividing the current sufficiently, and unprofitable from the rapid loss of power when the current is divided at all. As Professor Morton explained lately, when the intensity of the light is diminished by subdivision the percentage of light decreases enormously; so that where a given electric force, applied to one lamp, gives a light, say, of eighty burners, it will with two lamps give only as much light as thirty burners.

Whether Mr. Edison has overcome all these obstacles to the economical use of electricity in small lights remains to be proved. Nevertheless, his invention seems to have been the occasion of something like a panic among the holders of gas stocks, a panic which would be foolish even were everything claimed for the invention absolutely true and certain, as a little unexcited thought with regard to the nature of gas, and the vast undeveloped fields of usefulness open to it, will show.

But what is Mr. Edison's discovery? A few words will suffice to give an idea of it. It is based on the well-known fact that a wire may be heated by an electric current, the basis of many attempts to accomplish what Mr. Edison claims to have done. The reader may have seen the gas jets of the dome of the Capitol at Washington lighted by similar means. Over each burner is placed a coil of platinum wire, which, when heated by the electric current, ignites the gas. Mr. Edison uses the coil itself as the source of light, the current sent through it being strong enough to make the coil white hot, or self luminous. The difficulty to be overcome at this point was the liabilty of the wire to fuse and spoil the light; a difficulty which Mr. Edison claims to have obviated by the introduction of a simple device which, by the expansion of a small bar the instant the heat of the coil approaches the fusing point of platinum, interposes a check to the flow of the current through the coil. This automatic arrangement, in connection with an auxiliary resistance coil, secures, it is said, an even flow of electricity through the coil, and consequently a steady glow of pure light. If this is done economically, it is obvious that a marked advance has been made in artificial illumination.

Must gas go out in consequence? Our opinion to the contrary has already been expressed. The communication from Mr. Strong relative to the use of gas as fuel may be read with interest in this connection; it will be found in another column. The enormous capital invested in gas works and street mains is in no danger of being made useless. Whatever may come out of the electric light, the demand for gas is sure to increase enormously. By recent improvements in the processes of gas making, it has become possible to supply this most perfect fuel at rates which must rapidly do away with all other fuels for most domestic and other purposes; and it is quite possible that the gas that will be required for supplying power for the generation of electricity, supposing the use of electricity to extend as its advocates claim, will amply compensate for all that is likely to be withdrawn from public consumption by the advances of the new light. At all events, the holders of gas stocks will do well not to sacrifice their property in consequence of this temporary and uncalled-for flurry.

A TELEGRAPH TO SOUTH AFRICA.

TO THE EDITOR OF THE TIMES.

SIR: On the 30th September, 1876, you were good enough to insert a short letter signed "H. B. T. Strangways," on the subject of an overland telegraph between the mother country and the South African Colonies.

Having for some time past taken a special interest in this proposal, and seeing now that the project is advocated by influential men, both in this country and at the Cape, I venture to ask for a small space in your influential journal for the purpose of directing public atention to the subject.

The necessity of having communication by telegraph between England and the Cape of Good Hope is now admitted, both by the Imperial and the local authorities; and, as an earnest of this, I may mention that the Legislature of the Cape have just passed an Act authorising the payment of a sum not exceeding 15,000*l.* a year for fifteen years as a subsidy in aid of the undertaking. The Government of Natal has also voted 5,000*l.* a year for the same purpose, and the most important question now for decision is—which is the best route to follow in the case. In my humble opinion, the advantages which would accrue by the construction and maintenance of a line of telegraph through the centre of the African continent are numerous and overwhelming, as compared with those derivable from the laying down of a marine cable by way of Zanzibar and Mauritius to Aden.

The establishment of the former would not only put the South African Colonies into immediate communication with England and other great centres of trade, but would eventually open up a vast field for commercial enterprise.

The maintenance of a line of stations along the proposed route would, by striking at the very foundations of the slave trade, do more towards abolishing that inhuman traffic than the expenditure of tens of thousands of British treasure in keeping up a fleet of cruisers on both coasts of Africa. Mission stations would be protected, savage tribes civilised, and in a few years a complete revolution would be effected in the bearing and character of the many millions of human creatures inhabiting that extensive country.

It may not be generally known that land lines of telegraph already exist between Alexandria and Khartoum—some 1,100 miles up the Nile—while, on the other hand, the Cape lines have already been completed as far north as Port Durban, Natal, so that, as the crow flies, there is really only a gap of about 2,500 miles to be filled up. The cost of the line across the Australian continent was about 160*l.* per mile; but, supposing this should amount to 200*l.*, only half a million would be required for its construction, while the lowest estimate for a cable line *viâ* Aden is 1,200,000*l.*

Apologising for the length of this communication,

I am, &c.,

THOMAS WATSON,

President of the Cape Town Chamber of Commerce.

London, Oct. 24.

[The above letter appeared in *The Times* a few days ago, and the following upon the same subject, addressed to Mr. Sievewright, the Director of the Cape Telegraphs, by Mr. Mayes, Engineer in charge of the East African Expedition, has been sent direct to us.—ED. E.]

Der Es Salame, 15th July, 1878.

I have just received a cutting from a newspaper from home, stating that there is now great agitation there and at the Cape with regard to an overland telegraph route through Africa in place of a submarine cable, and it states that, in a paper read by Mr. Sievewright, he advocates the overland route. (I have left the paper referred to at my camp, so cannot refer to names or plans.)

I must give you my opinion on such a route, and should advise you, if you ever wish to have telegraphic communication, it must be by a submarine cable. To construct a land line through Central Africa would take years to accomplish, and, when it is finished, by what means will you keep up communication? These are points I should like to hear about from those agitating in favour of this route. Is there one person among them who is a practical telegraph engineer or electrician? If so, what is his knowledge of East and Central Africa, and the difficulties to be overcome?

Seeing the difficulty is even to travel through this country, I think you will find your estimate fall very short of the mark, even in first construction; and what will be the cost of maintaining such a line, supposing it were constructed?

I see you mention the name of Colonel Grant, R.E., who states that the Egyptian Government are carrying their line up the Nile. I have no doubt they will construct telegraph lines as fast as Colonel Gordon advances, as he has the country all open behind him, and under the control of the Egyptian Government,

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where it will be easy to protect it when once constructed. But when you leave Colonel Gordon and try to reach Ujiji, on the eastern side of the Lake Tanganyika, and from thence to Zanzibar, it is a very different matter.

What route do you propose to take from Zanzibar to Natal? One of your schemes is to go to Ziti, on the Zambesi; but I will defy any company to carry a line along this route, within a space of five years, from no other cause than the nature of the country itself.

I had a long interview with Colonel Grant before I left England in March, 1877, but our conversation was more on the construction of roads than telegraphs; but, at that time, I was not so well acquainted with East Africa as I am now. I have met with missionaries and engineers from almost every part, and have had conversation with them, and almost all our travellers in these parts, on the subject of the country.

Your greatest enemy to contend with, for overland telegraphs through Central Africa, is the rapid growth of vegetation. On this point I had a good schooling in India, as, on the commencement of the lines there, in 1853, I was entrusted with the construction of the lines through Kandish and the Sindwar Jungles to Indore. Here I had first-rate timber, leaving my wire 18 and 20ft. clear of the ground.

But, to our dismay, as soon as the monsoon commenced, telegraphic communication ceased, from the rapid growth of vegetation. Where we had gone over cultivated ground, such as Joaria, the corn very soon reached the wire, and the heavy weight of corn pulled the line to earth; likewise, the wild runners in the jungle climbed the poles and ran along the wires.

If vegetation would have such effect in so short a time in India, what must it do here, where vegetation grows so much faster and ranker?

You must know that, from the sea coast of Eastern Africa for 400 or 500 miles inland, in every direction, there is nothing but tracts of forest and thick jungles to encounter throughout. To construct a telegraph line, you would have to cut and clear, and your clearance must be of such a width as to insure against the trees coming in contact with your wire.

I will give you an instance of what has taken place on my road, which will give you some little idea of the rapid growth you will have to contend with. Just a year ago I commenced to construct a road for the purpose of general traffic from Der Es Salame, with the intention of taking it to the north end of Lake Nyassa. I had constructed fifteen miles of such road, when I was ordered to proceed to Kilwar, and make a survey of the route travelled by Von Decker in 1850; but, from the limited time I had, having to meet the steamer again on her return, I could not get further up country than Kingaru, being about 120 miles from the coast; and, although I had letters of introduction from the Sultan to the governor, and he appeared to be all kindness, behind the scene he was doing all in his power to delay my departure, and threw all the obstructions he could in the way. I found the engineering difficulties quite as great from this point as they were from where I had commenced. On my returning to Zanzibar I went home to England. My assistants, the two sons of Dr. Moore, of Edinburgh, carried on the work in my absence, and, on returning to my post again, at the end of January, I found they had made the road, a distance of twenty-eight miles. But, what was my surprise on going over the road which had been made, in some parts for miles at a stretch, I could not see any signs that a road had been constructed at all. In many places rank weeds had grown to the height of twenty feet, and in many places, where it passed through thick jungle, the underwood had so spread that it would have been impossible to have taken an ox waggon or cart along without recutting, although this road was constructed twenty feet wide. It has now taken me two months, with upwards of forty men daily, to clear this road.

Now, if a road of this description and width, where all care and pains had been taken to grub up every root, will close up in so short a time, what would happen in the case of a road merely cut for a telegraph line?

If you went to the expense we have done for a clearance, and nothing less would do, I think you will find your expenditure will exceed that necessary to establish a submarine cable. Such a road would certainly have to be cut, or it would be impossible to transport your materials. It must be understood that all the carrying power of this country is by coolies on their heads. Now through much of this country you will not only have to find coolies to carry your materials, but you will also have to find coolies to carry provisions, for in many places there is no food to be procured, and you must carry merchandise to purchase it, as money will not do where it is to be got.

I must inform you that I am not the only one trying to open up roads for trade. The Church Missionary Society have had an engineer at work these last two years trying to open a road for ox communication from Saddena to Enpwapera, and they have not met with even as good success as myself. Further, it is twelve months since the Rev. N. Price started with a party of six Europeans to try to reach Ujiji. He took cattle and men from the colony to assist in his undertaking. What was the result? Why, the whole of the oxen died off. His men fell sick and died. I believe, at the present time, they are not advanced more than one-fourth of their journey. Now, who is to look after the line when it is constructed? Certainly, not the natives of the country without some close supervision over them; and who are to be your inspectors? And such inspectors, it must be understood, will have no other mode of travelling than walking; and even these people would require a large staff of coolies for this work to carry provisions, bedding, a tent, and such things. And it must be remembered that, in carrying provisions, you have not only to carry for yourself but also for your carriers, and these men will not carry on an average more than 60lbs. a load.

I am trying what I can do to keep my road clear with natives under the different chiefs of villages and districts I go through. They will promise most faithfully to see that they will find men to do it, and take your money. But you will find at the end of the month no work has been accomplished. When this is not to be done under the Sultan's control, and with his orders, how are you to maintain long stretches of telegraph lines? Not without a large and expensive staff of Europeans to look after it. Here, again, you will find another great difficulty. The climate is such that it upsets all who come here. Europeans stand it better than others. I had seven men sent me from Aden, natives of Bombay, in November last, and on my return from England in January I found two of them and one of their wives dead. The others were so ill that I ordered them to the coast at once, to be sent back to Aden by first steamer. One of these died on his way to the coast, though only twenty-eight miles distant.

I brought an Arab with me from Aden as a head man. He was not here a month before I had to send him back to save his life. I myself have severe attacks every two or three weeks. I am expecting assistants out from England next mail, and, as soon as I have started them on their work, if I can stick out so long, I must return home again.

I think this statement should show you something of the difficulties you would have to contend with in putting up a telegraph line through Central Africa. If such a line should ever be started, it certainly should not be an overground line, but a subterranean.

In the same paper a comparison is made between a line through Africa and the lines constructed though Australia, Mesopotamia, Persia, Russia (through Siberia), and America.

I have to say that these countries presented no difficulties at all to be compared with Africa. I myself can vouch for three, Mesopotamia, Persia, and Russia. For instance, in 1863, I went out with Lieut. Smith (now Major R.E.) and twelve non-commissioned Royal Engineer officers, for the purpose of constructing the lines in Persia and Mesopotamia. Lieut. Smith commenced with six of the men at Bussorah, whilst I went on to Bosora, and commenced the land lines from Fao, the landing place for the Persian Gulf cables, taking it to Bosora, and across by the holy city of Hillah or Babal, on to Bagdad, from which place the line runs to Kermatha, the boundary town between the Turkish Dominion and Persia, and from there to the town of Hamardam, and on to Teheran, from there to Espan Shearas and to Bushire, where it joins the Gulf Cable again.

There was not so much trouble in erecting the lines through Mesopotamia as there would have been in doing the same amount of work in England, for the country is one flat desert, where lines were taken from twenty and thirty miles in one dead line, which makes it the finest (line) in the world. The line itself is constructed with Siemens' patent iron poles. These were easily distributed by boats on both the Tigris and Euphrates, at stations never more than twenty miles apart, and with plenty of pack horses to distribute them. Persia, again, is an open country, with nothing to obstruct you except a few mountain passes to overcome. What is this to our dense forest and jungle? Labour in both countries (Mesopotamia and Persia) can be got in abundance, and, as for maintenance of a line, there is no country in the world where it is more easily protected than here. There are good and fleet horses and camels, and one man can well look after sixty miles of line. Where, then, is your comparison of these countries with Central Africa?

On my return from the Persian Gulf, at the end of 1865, I went out to Russia, at the request of Mr. Latimer Clark, for Sir Morton Peto, to superintend the construction of lines from Dendenerg to Wetaps, and the only difficulty the engineers met with in putting up the line through Russia and Siberia was want of carriage. The only forests they had to contend with were pine forests, without any underwood or scrub. I have had conversations with two

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of the Danish engineers who assisted in constructing this line, as they were under my instructions in Mr. W. T. Henley's cable factory, where we were making the great northern cable for Japan and China.

Whoever brings these lines up in argument to prove the possibility of carrying lines through Central Africa must know very little of the subject he is speaking about. There are, I know, fanatics in the world who will start a project, and no persuasion or proofs can turn them from it; *but I hope the public of the Cape Colony will not be so insane as to lay out their capital on such a speculation as telegraphic communication with Europe through Central Africa for this next ten or twenty years at least. It will come, but not in my time.*

I should have thought the Cape people would not be advocates for long land lines, seeing how badly their own line used to work from Cape Town to Port Elizabeth when I was in the Colony.

There was, in general, three days out of every week interruption between the two places, and a temporary interruption with every shower of rain.

What, then, could be expected in the interior when, under the directors' own eyes, the faults lay glaring enough to any man who knew anything about electricity? During the few days I remained in Cape Town I went a short distance by rail, and within twelve miles I counted sixty-seven places where the wires were in contact with the hedges and trees.

It is time the colony had telegraph communication with the mother country, and the only way is by cable to Aden, leaving it an open question as to what places should be taken in *en route*. But I myself should recommend the cable to go from Natal, through the Straits of Madagascar, touching at whatever ports may be suggested by more competent persons in mercantile affairs than myself, but touching at Zanzibar, which is becoming a flourishing port, and will well pay its share in traffic between there and Bombay. Here are upwards of 8,000 British subjects carrying on a great trade with Bombay and the whole of the coast of Cutch. They are speculative, and would use the line to a great extent. They are the chief supporters of the lines in India.

From Zanzibar, I should take the line direct to Aden, keeping well in sight of land, where, I believe, a good sandy bottom would be found, and in comparatively shallow water, where it would be always easy to pick up for repairs, if required; but, from Cape Gardefu to Zanzibar, I believe a level bottom would be found the whole distance, with not more than 200 to 400 fms.

From Zanzibar, I should have a branch line to Mauritius. The cables should be landed in a bight at Urun, to the north (or) Chuka Bay, on the east side of the island, when a land line of about five miles would carry it to the town of Zanzibar. The nature of the country would be favourable for a subterranean line, which would leave the cables completely safe from lightning.

I hope these few remarks may be the means of bringing the advocates for a land line to unite with those who support the submarine cable scheme, and, by unity, make sure of the only route open for establishing this communication.

I beg to remain, dear sir, your obedient servant,
(Signed) W. Mayes,
Engineer in charge of East African Expedition.

TAKE NOTICE!

[A humble voice from America.]

I'm the greatest genius going, and the talents I possess
"Are enough to stock the world,"—please, see the New York Press;
And I give you now fair warning that I claim in every land
What could, would, should, or might come, of all I take in hand.

I may mention, for example, with my *newest* Telephone
You'll hear to-morrow's rumours;—so let Telephones alone;
And the Phonograph I'm *making* will take part in a debate;
I'm *going* to do a lot of things,—so you are all too late.

They've contrived Electric Lighting, without consulting me,
On your side the Atlantic;—this is downright piracy!
But I've taken out a patent that will cover all that's known,
And—when I've *thought it over*—I shall count it all my own.

And, lastly, as a clincher, I've determined in my wrath
To patent Electricity, and Magnetism, both:
If this is not effectual to answer my intent,
I guess I'll take a patent for my sole right TO INVENT.

November 5th, 1878. F. Unney, Contributor.

FORMULÆ RELATING TO THE ELECTRIC LIGHT.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: The following formulæ may be of use to electricians and electrical engineers engaged in producing light by the agency of electricity:—

Let E = the electromotive force, in Volts, acting in a circuit;
R = the total resistance, in ohms, of the circuit;
r = the resistance of the voltaic arc obtained;
H.P. = the horse-power of the prime-motor used to work the dynamo-electric machine; and
h.p. = the horse-power absorbed in the production of electrical work.

The energy of the current, or the mechanical equivalent of the work and heat produced by it *per hour*, will be

$$W = \frac{E^2 \times 2654}{R} \text{ ft.-lb.} = \frac{E^2 \times 1{\cdot}18}{R} \text{ foot-tons.}$$

The horse-power absorbed in the current $\left(\frac{\text{energy in ft.-lb.}}{33{,}000 \times \text{time in min.}}\right)$ will be

$$\text{h.p.} = \frac{E^2}{R \times 747}.$$

The ratio $\frac{\text{h.p.}}{\text{H.P.}}$ is the measure of the efficiency of dynamo-electric machines. In the case of Gramme's machine, under the best conditions, we have

$$\text{H.P.} = \text{h.p.} \times 2{\cdot}63.$$

The horse-power absorbed in the arc itself is

$$\text{h.p.} \times \frac{r}{R}.$$

The ratio of this latter value to h.p., or

$$\frac{\text{h.p.} \times r \times 747}{E^2},$$

is the measure of the efficiency of the electrical circuit in the production of the greatest quantity of light with a given quantity of electrical energy.

In the experiments with Gramme's machine made by the Committee of the Franklin Institute, the light, in standard sperm candles, produced by the voltaic arc was

$$\text{h.p.} \times \frac{r}{R} \times 1{,}048 \text{ (candles)};$$

or, calling I the current in vebers per sec., the light in this case was

$$I^2 r \times 1{\cdot}4 \text{ (candles)}.$$

This may probably be taken as a safe *minimum* value for small lights; but it would appear that the quantity of light increases more rapidly than the square of the current, or that the light is most economically produced when it is least subdivided. With the larger magneto machines, worked with greater horse-power, the constants for the two latter formulæ would be, in fact, considerably higher, provided one light only be obtained.—I am, &c.,

Desmond G. FitzGerald.

ELECTRIC LIGHTING.

*On the Present State of Electric Lighting.**

By J. N. Shoolbred, B.A., Mem. Inst. C.E.

Electric lighting has only attained to its present development by certain marked stages of progress.

Its first stage, at least of practical application, may be identified with the large, cumbrous, magneto-electric machines of Holmes, and of the Alliance Company, producing a current alternating in direction, and supplying a single light, the sole application of which seems to have been confined to a few light-houses.

The next stage is represented, in this country at least, by the dynamo-electric machines of Gramme and of Siemens, which supply a much augmented current, continuous in direction, to a single light; and whose application includes, besides light-houses, the illumination of workshops and other large areas. The third and present stage is that of the divisibility of the electric light, *i.e.*, the production of a number of lights from a single source of electricity.

This last stage has been arrived at likewise with dynamo-elec-

* Read before Section G of the British Association: Dublin meeting.

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tric machines; both from those giving continuous direction currents, and from those alternating in direction, but chiefly with the latter.

The Jablochkoff candles, the Lontin, and also the Rapieff systems have effected this much desired development in electric lighting.

FIRST STAGE.—The electric light was first produced at the commencement of the present century by Sir Humphrey Davy by means of a powerful battery of 3,000 cells. The light is supposed to be mainly due to the incandescent particles of carbon which keep passing between the points. No practical result followed from this experiment, as might be expected, owing to its expensive character.

It was not until Faraday's discovery of the induction of currents by magnets in 1831, leading to the construction of magneto-electric machines dispensing with any battery, that the production of the electric light was practically applied. Machines of this character, at the suggestion of Professor Nollet, of Brussels, were produced in 1849 by Holmes, of London, and by the Alliance Company, of Paris; their principle being, that by the rapid rotation by mechanical means of an induction coil, composed of copper wire wound upon a soft iron core, the magnetism present in a number of permanent horseshoe magnets ranged exteriorly around the periphery of the coil is induced into the coil, whence it is utilised and led off for the production of a single electric light.

Machines of this character have been placed at the lighthouses at the South Foreland, at Cape La Hève, and at Cape Grisnez, in France, and at several others in the north of Europe.

That at Cape La Hève (constructed by the Alliance Company) has on each cast-iron frame eight rows of compound horseshoe magnets fixed symmetrically. There are seven of these frames, each separated from the next by a space. Within the six intervening spaces are placed six wheels, each carrying at its circumference sixteen coils, corresponding to the poles in each circular set. Each soft iron core has its magnetism consequently reversed sixteen times during each revolution by the influence of the sixteen successive pairs of poles between which it passes, causing the same number of currents in alternate directions to be generated in the coils. These currents are transmitted unchanged to the carbon points, the positive ones being collected on the axis of the machine; while a concentric, but insulated, cylinder is used for the negative ones.

This machine is large and cumbrous, being 5 ft. 3 in. long, 4 ft. 4 in. wide, and 5 ft. high; it weighs about 2 tons, and costs 450*l*. Its illuminating power, when driven at a speed of from 350 to 400 revolutions per minute by a steam engine, with an expenditure of somewhat over three indicated horse power, is about that of 2,500 standard sperm candles per hour.

The use of the large, old-fashioned and comparatively weak machines of this Holmes-Alliance stage may be said to have passed away, being only retained in the lighthouses above mentioned. Their only recent application, and that was but of short duration, was to provide the alternate direction currents necessary for the Jablochkoff candles when first introduced, and until M. Gramme had devised a suitable machine for their proper supply. Quite lately, however, a modified form of machine, much reduced in size and weight, has been designed by M. de Meritens; in order to compete with the small and compact dynamo-electric machines of the present day.

SECOND STAGE.—Between the period of the construction of the machines of the former stage and those which mark this second period, a very great advance was made in the construction and efficiency of electric light machines. This is due to a discovery made almost simultaneously in 1867 by Dr. Siemens, by Sir Charles Wheatstone, and by Mr. S. R. Varley. If an induction coil be made to revolve in front of a soft-iron electro-magnet, instead of before a permanent magnet, as in the earlier machines, the small amount of residual magnetism always latent in the iron, especially if it has been once magnetised, causes feeble currents to be induced in the coil; and, if these currents, or a portion of them, are sent round the iron magnet, *i.e.*, into the wire surrounding it, the magnetisation of the iron is increased. This, again, produces a proportionate increase in the induced currents in the coil; and thus, by a series of successive mutual actions, intense magnetisation and very powerful currents are produced. Machines constructed upon this principle of reaction (*i.e.*, in which electro-magnets are used) have been termed "dynamo-electric" machines, as indicating that dynamical force is converted into electricity; and which is gradually augmented in intensity. While for the older form, where permanent magnets are employed, the term "magneto-electric" machine has been retained; their power being limited to the strength of the magnetisation of the permanent magnets made use of. This discovery, by adding considerably to the power of electric machines, led to a corresponding diminution in their bulk and also in their costliness. Almost all, if not quite all, the subsequent machines, not merely of the second stage at present under consideration, but likewise of the more recent ones are "dynamo-electric" in construction, and are based upon the principle of "mutual reaction."

A distinguishing feature of the machines belonging to this second stage is that they produced currents of considerable intensity, all of which were collected upon the circumference of a circular disc termed a commutator, the currents circulating upon one-half of its circumference being opposite in magnetic direction to those upon the other half, a separate contact brush serving to carry off the current from each half. The currents from these machines thus passed off in one continuous direction, and were not subject to a constant series of reversals in direction as with the earlier machines. The currents were supplied for the production of a single electric light. The machines of this type which are best known in this country are the Siemens and the Gramme.

The *Siemens Machine*.—It consists of an induction coil, with the convolutions of the copper wire wound lengthwise with the cylinder, in the form known as the modified Siemens armature. This coil is made to revolve by mechanical means between curved iron bars, which are the prolongation of the cores of large flat electro-magnets placed on either side of the induction coil; the north pole of the system being midway between the two upper electro-magnets and directly over the axis of the coil, and the south pole in a similar position below the axis upon the bar between the lower magnets.

The portion of the coil, which during its revolution is travelling downwnwards, has (with the above arrangement) positive currents induced in it; while the ascending half of the coil is subjected to negative currents, but both in the same direction as regards circuit. The arrangement of the poles may, however, be exactly the reverse of the above.

—		Revolutions per minute.	Illuminating Power. Standard Candles.	Actual Horse Power requird	Weight.		Cost
The Siemens machine is, as stated by the makers, usually made in the following sizes and capacities, viz.:					cwt.	qrs.	£
	A	850	1,200	2	2	2	70
	B	650	6,000	4	3	3	112
	C	360	14,000	8	11	2	250

The Gramme Machine.—This machine in its earliest development was an adaptation of the heavy Alliance type of alternating direction currents of the first stage already spoken of. Its very existence is nearly forgotten; and it is only referred to here merely to mention, that this is the form of Gramme which in the Trinity House experiments (of which later on) was pitted against the Holmes, the Alliance, and the Siemens just described. This earliest type of the Gramme machine formed, in part, the basis of the latest or third form; also an alternate direction current machine, which will be described farther on when treating of the divisibility of the electric light.

The type of Gramme here about to be described is the second form, based upon the principles of the dynamo-electric machine, and supplying a continous direction current to a single light; a machine very similar in construction and principle to the Siemens one just described. It is the machine referred to by Mr. Douglass, in the concluding paragraphs of his report upon the Trinity House experiments at the South Foreland, as having been the object of his special visit to Paris.

It is composed of an induction coil, having for its core a ring or cylinder of soft iron, which is made to revolve mechanically between two round bars, each forming the core of a pair of electro-magnets. These bars are placed one directly over, the other beneath the axis of the coil and lengthwise with it. Each bar extends from one cast end-frame piece to the other side of the machine; while its middle is clipped by a sort of ring of cast iron, which serves to divide the coils wound upon the half bar on either side of it, and thus forming them into two electro-magnets. These are so arranged, that the pair on each bar have like poles next to each other at the centre next to the cast ring, which serves as a double pole to convey the combined electricity to the revolving induction coil, by means of its jaw-like projections which are splayed over the coil, so as to embrace it as closely as possible without touching it.

As in the Siemens machine, the double pole of the upper bar is opposite in character to that of the lower one. Similarly also are the induced currents in the descending half of the revolving coil like in nature to the upper pole; while those in the ascending half follow the lower pole. Two brushes, tangent to a circular

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commutator placed on the induction coil shaft, carry off the electricity in one continuous direction.

—		Revolutions per Minute.	Illuminating Power. Standard Candles.	Actual Horse Power requird	Weight.		Cost
The Gramme machine is stated by the makers to be usually made in the following sizes and capacities, viz..					cwt.	qrs.	£
	M	1,600	2,000	1½	1	2	70
	A	900	6,000	2½	3	3	100
	C	700	15,000	5	8	0	300

The machine " A " is of 6,000 candles illuminating power, and it is the one generally made use of in industrial works and other similar applications.

Reference has already been made to a series of experiments made by the Trinity House at the South Foreland Lighthouse. They were carefully devised and carried out in 1876-7 by their engineer, Mr. James N. Douglass. They consisted in comparative trials between the Holmes, the Alliance, the Gramme (old model), and the Siemens machines; the three first-named representing the old obsolete magneto-electric machines, and the last-named the improved dynamo-electric form of construction. The Siemens machine was considered to have performed the best; a result which ought not to excite surprise when placed in such company. Though the dynamo-electric Gramme, just described, was not experimented upon in the trials, Mr. Douglass at the end of his report refers to an inspection which he made in Paris of the performance of one of these machines (A); he did not, however, consider it superior to the Siemens machine B, corresponding to it in size.

These experiments are very important, as they afford a means of comparison between the efficiency of the first class of electric light machines, the magneto-electric, and those of the second class, the dynamo-electric.

The value of this comparison has been still further enhanced by the experiments of the Committee of the Franklin Institute in Philadelphia on dynamo-electric machines, carried out in 1877-8, and recently made public. They had under comparison the Gramme (" A " size), the Brush (large and small size), and the Wallace-Farmer (large and small size). Preference is finally given to the small Brush over the Gramme, which is admitted to have run it very close. The grounds for the preference seem, however, somewhat paradoxical.

Third Stage.—The third or present stage of electric lighting, which represents the divisibility of the current so as to produce a number of lights, though sought after by many during the last twenty years, has so far only been *practically* solved by the Lontin and by the Jablochkoff-Gramme systems. Both have found it advantageous to work with alternate-direction currents, but the arrangement used by each for the production of the electric light from those currents is different. M. Jablochkoff makes use of any machine giving alternate direction currents, a *sine quâ non* with the " candles " which bear his name. At first he was compelled to use the Alliance machine, failing any other, but more lately he has been enabled to make use of an improved dynamo-machine which M. Gramme has recently devised to give off alternate-direction currents, and which will be described further on after the Lontin machines, which preceded it in point of time of appearance.

The Jablochkoff " candle " being merely a lamp or regulator, will be described among those ingenious apparatus.

The Lontin Machine.—M. Lontin, unlike M. Jablochkoff and M. Gramme, each of whom attacked only a portion of the question of the divisibility of the light, has boldly faced the entire of the difficulty and has offered a very satisfactory solution of each part of it. He has designed a special form of machine, or rather two distinct machines to effect the object desired. In the first, which may be termed the " generating " machine, the electric currents, feeble in intensity, are excited; they are passed off in one continuous direction to the second or " dividing " machine, which, after greatly augmenting their intensity, permits of their being collected from off its exterior casing in a form divided and sub-divided almost at will, and alternating in direction; this last being in his opinion the description of current most suited for giving a pure steady light, and one not subject to reproduce sympathetically the disturbances occurring in other lights which occur on the same circuit. The latter object M. Lontin effects with several forms of lamp, some being modifications of other systems, while others are entirely original in their mechanism and regulating apparatus.

The " generating" machine consists of a horseshoe electro-magnet, having its two arms placed vertically upwards. Between these arms rotates an induction coil, in form like a pinion; the cylindrical teeth, round which the coils are made, are fixed radially into a core or revolving axle of soft iron. A number of these pinions, proportionate to the required strength of the machine, are added side by side on the core, each pinion forming a complete circuit of itself. In the arrangement of these pinions upon the core common to all, it will be noticed that the corresponding teeth of these several pinions are not ranged in a horizontal line lengthwise along the revolving shaft, but in a spiral. By this means any interruption of interval between the passage before the poles of the electro-magnet of one set of teeth of the induction coil and that of the succeeding set is avoided. Two friction rods collect one the positive, the other the negative currents, which are passed off through the coils of the electro-magnet, thereby intensifying its action, and so in one continuous direction to the second machine.

This second or " dividing " machine consists of a revolving drum, carrying, fixed exteriorly like the spokes of the wheel, a series of electro-magnets, into the coils of which the currents from the " generating " machine are passed, and which are always kept thereby in magnetic saturation.

This magnetic wheel revolves within a fixed wrought-iron cylinder, having on its inside a number of induction coils corresponding to that of the radial spokes in the revolving wheel. The coils of these spokes are all coupled together, but in such a manner that while one spoke-magnet has its positive pole at the outside extremity next to the induction coils, the succeeding spoke will present at the outside end its negative one; and so on are the spokes made to alternate in their poles round the circumference of the revolving wheel. The result is that the latter, during its passage, induces a number of currents alternate in direction, and equal in number to half that of the spokes. Each of these currents is collected directly and separately upon the fixed exterior drum, and conveyed to a manipulating frame outside, where by suitable arrangements the various elementary currents may be coupled and combined together in one or in any desired number of circuits. The apparatus in the diagram having twenty-four spokes can, by coupling them in pairs, produce twelve circuits, or any lesser number which may be desired. And, furthermore, the entire of the current of each circuit may be devoted to a single lamp, or to the production of a series of as many lights as it can support.

These are facts which seem to indicate that an electric supply may be broken up and divided into a series of separate lights, where the number, as well as the luminous power of each can be varied at will; only limited by the powers of production of the machine.

The double Lontin machine is capable of supplying a total illuminating power of 12,000 standard candles, if the generating machine is driven at 220 revolutions per minute, and the distributing at about 360; but a much larger illuminating power may be obtained if driven at a proportionately higher speed. The usual motor is an engine of eight-horse power nominal; the number of lights generally produced varying from six to twelve, the luminous intensity of each diminishing as the number is increased, but as many as thirty have been supplied from it for a length of time at one of the railway stations in Paris, where a higher rate of production than above given was required.

The Gramme "Dividing" Machine.—Reference was made a short time back to this the latest development of this machine.

To relieve M. Jablochkoff from the necessity of making use of the cumbrous and comparatively weak Alliance machine, and yet to afford a supply of alternating direction currents, M. Gramme lately devised this machine to be supplied with a previously created electric current; his own continuous current machine (previously described) serving as a " generator" for this current. The arrangement and the combination arrived at has a strong resemblance (superficially at least) to that previously arrived at by M. Lontin.

The machine consists of a revolving cast-iron drum on a steel shaft, having eight electro-magnet flat bars placed radially like the spokes of a wheel; to this revolving system is supplied the electricity generated in one continuous direction by the generating machine. Upon a soft-iron cylinder fixed exteriorly to this magnetic wheel are a series of coils lengthwise with the barrel, and dividing up the entire cylinder into a number of segments—32 in the present instance. The current is taken directly and separately from each of these segments to form one or more circuits as desired; 32 being the maximum number in the above machine, though these are in practice coupled together so as to be reduced to four. The luminous intensity of this machine is of 16,000 candles. As applied in lighting a portion of the Avenue de l'Opéra in Paris to 16 Jablochkoff candles, it is driven at 600 revolutions per minute, and *is stated* to require an engine of 16 nominal horse power.

[To be continued.]

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EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY (LIMITED).

The tenth ordinary general meeting of the shareholders of this Company was held on Wednesday, November 6, at the Cannon-street Terminus Hotel, under the presidency of Mr. John Pender, M.P., chairman.

Mr. F. E. Hesse, the secretary, read the notice convening the meeting, and the minutes of the general meeting, held on the 11th of April last, which were unanimously confirmed by the present meeting, and signed as correct by the chairman.

The Chairman then said: Gentlemen, before asking you to approve the report, I presume you will take it as read, as you have had it in your hands some days. [It appeared in *The Electrician* of last week.] I am glad to congratulate you so far that our cables are to-day all in good working order. We have not been able to say that very, very often, during the last six months; but, at the present time, I am glad to say that our traffic is going on in a very satisfactory way. I, as usual, will give you some of the items referred to in the accounts, so that you may know of the increase and decrease which has taken place during the last six months. The gross earnings for the half year ending the 30th of June amounted to 135,482*l.*, against, for the corresponding period of 1877, 140,436*l.*, or a decrease of 4,954*l.* Of this amount nearly 2,000*l.* is loss on exchange, the remainder being due to a slight falling off in the revenue, which, I am glad to say, has since been made up. The expenses for the half year under review are :— 61,222*l.*, against, in the corresponding period of 1877, 48,417*l.*, showing an increase this half year of 12,805*l.*, which is accounted for in the following manner :—Station expenses show an increase of 2,690*l.*, caused principally by the opening of the Rangoon cable, and the extra staff required for giving a night service to Australia during the recent European crisis, and for establishing duplex working on the Madras-Penang cable. That is 2,690*l.* The expenses of conference at Melbourne were 899*l.*, cost of new land lines and instruments for the establishment of the duplex principle 4,342*l.* These are sums which, of course, will not be repeated, and I may mention, in regard to the duplex principle, that we find it gives us, practically for working purposes, an additional cable. We can now, by this principle, send as many messages the one way as we receive the other, both messages going on at the same time. Therefore, it has practically, as I have said, given you an additional cable. That is an amount, however, which will not be repeated again. The repairs were heavier than in the corresponding period of 1877 by over 3,000*l.* These repairs have been, to a considerable extent, caused by the teredo, a small insect found very much in shallow water of high temperature, and particularly where there is any flow of fresh water into the sea. The result has been that we have had repeated repairs. They are small in themselves, but, still, a pin's point causes as much interruption as if the cables were cut to pieces. This has been the cause of a great deal of attention being turned to these insects and their action on the cables ; and, in connection with the Telegraph Construction Company, I am glad to say that we have got now something like 150 miles of experimental cable which we believe it will be impossible for any insect to penetrate. That is being tried at different points of our system, and I hope that we shall be able to obviate this great drain on our resources for repairs. I may mention that the Telegraph Construction Company have paid half the cost of the experimental cable. Then, there is another amount, the depreciation of ships, previously written off, at the end of the year, 2,000*l.*, making up the whole of the increase. In other words, I have shown you that the station expenses increase is 2,690*l.*, and that is likely to be permanent; the expenses of the conference at Melbourne, 898*l.*, are exceptional ; the cost of the new land lines and instruments for the establishment of duplex—also exceptional; heavier repairs than during the corresponding period is an uncertain item ; depreciation of ships will continue until we write them down to a point at which we can sell them. The net revenue for the half year under review is 74,260*l.* ; in the corresponding period of 1877 it was 92,019*l.*, showing a decrease of 17,759*l.*, which is explained as above. Two interim dividends of 1¼ per cent. each have been distributed, absorbing 49,937*l.*, which leaves 24,323*l.* to be carried forward, against 13,299*l.* in the corresponding period, when 28,781*l.* was expended on the Rangoon-Penang cable. The cable repairs have not been less frequent than usual during the half year. Most of the faults are caused through the teredo, as I have mentioned. We have now on the station a new ship, the *Sherard Osborn*, and she arrived in time to do some good work for the Company. That ship has cost 45,000*l.* I have given you these figures to show you the working of the system, and I may also say that at the present moment our traffic is satisfactory, and, I think, showing an increase. The question that I expected to bring before you to-day at the special meeting is one which I assume will require to be postponed for a short time—namely, the duplication of the Australian cable. We have received telegrams from time to time from Colonel Glover, who is now in Australia, to the effect that he had got the different Governments of the colonies to agree to a duplication and to pay 32,400*l.* a year for twenty years [hear, hear]. We had brought it down to a satisfactory point, so satisfactory that we intimated to you that we are going to take powers to carry it out. Colonel Glover intimated, and was so assured by the Governments of New South Wales and Victoria, that the terms could be considered settled. They were settled so far as we approve and they approve, but they had to be confirmed both by the Parliaments of Victoria and New South Wales, the Governments having approved. The Parliament of Victoria approved of it unanimously ; it was received with great acclamation on both sides of the House, which is not very usual there. Colonel Glover was satisfied, from the assurance of the Ministers of Victoria and New South Wales, that there would be no difficulty whatever. However, it has occurred that the Parliament there have had two nights' discussion as to the duplication, and have made some alterations, which have to be referred to the Senate, where further alterations may be made, so that, at the present moment, the agreement which we expected to read to you to-day as completed is, for the moment, in abeyance. In a week or ten days, no doubt, we shall have the whole thing completed. I am perfectly satisfied, and have no doubt at all, that we shall arrive at a satisfactory solution, but I think it better that we should not discuss the question to-day further than that you should be made aware of the amount we are likely to receive, because in a discussion your directors' hands are tied; and we think it should be in abeyance till we can bring before you an agreement of which we can ask your approval. I shall propose after this meeting is over that the extraordinary meeting be adjourned for a month. With these remarks I shall conclude ; and, as no doubt, some shareholder may be desirous of putting some questions, I shall be happy to answer them, and to hear any gentleman on the different points I have referred to. The resolution I have to propose is, "That the report and accounts of the directors now submitted be received and adopted."

The Right Hon. W. N. Massey, M.P. (vice-chairman) : I beg leave to second that.

Some discussion then followed upon the accounts, in which Mr. Marshall, Mr. Christie, Mr. Abbott, and Mr. Newton took part.

Mr. Marshall : May I ask whether any other tenders have been asked for than from the Construction Company for the new cable? It is an important question.

The Chairman : It is a very important question indeed for the shareholders to have a cable in which they and the directors can have perfect confidence [hear, hear] and therefore I am prepared to answer, so far, your question. We have not asked for tenders from any other company but the Construction Company [hear, hear]. We shall get a special cable manufactured, and have requested one of the leading firms of electrical engineers of London—Messrs. Clark and Ford—to go most carefully into the cost of the cable, taking the whole of the different materials into account, and they gave us a certain sum. We also got Sir James Anderson, who has a technical knowledge of the value of these different articles, to go into it, and these two gentlemen came to within 8,000*l.* of each other as to the cost of the cable. I may tell you that, when we do make a contract for the cable, we shall save very considerably upon the estimate of the value of the cable that we got from our engineers, and also from Sir James Anderson. Having said so much, I think it must satisfy you that we have looked to quality, and we have looked to another thing. I hope that these debentures will be floated at 5 per cent., and our arrangement will be with the contractor that, if there is any difficulty at all in floating them, they will be ready to aid us in the transaction [hear, hear]. I can only tell you that, from the experience I have had of getting cables from other parties, I am here to prove by experts that what we have done with the Construction Company is cheaper and more satisfactory to us than you could have dealt elsewhere [hear, hear]. With these remarks, I beg to take the sense of the meeting on the resolution before them. Those who approve of it will please to signify the same in the usual way——on the contrary. It is carried with one dissentient.

The Chairman : The business of this meeting is closed, and we come to the extraordinary general meeting, and I beg to propose "That the extraordinary general meeting be adjourned to Wednesday, Dec. 4, at 2 p.m., at the Terminus Hotel, Cannon-street."

Lord William Montagu Hay : I beg to second that.

The Chairman then put the resolution to the meeting in the usual way for and against, and it was carried. He then said : That is all the business, gentlemen, and I hope that when we meet a month hence we shall be able to state that the contract is settled with Australia; and I would just say one word in regard to the contract—that I am perfectly satisfied that, if it is carried out in the terms and in the spirit which your directors have before them, it will give you an additional security, and I hope will materially develope the traffic between this and Australia. The Australians are so alive to the value of telegraphic communication with England that, as one of the speakers pointed out, as being a thing unknown to the colony before, they have really united to subscribe an annual sum for a duplicate cable, so as to ensure that continuous communication with England which they so much value. That continuous connection with England will give, at all events, an additional security to you [hear, hear].

A vote of thanks was tendered to the Board of Directors for their able management of the Company's business.

TELEGRAPH SHARE LIST.

Companies.	Closing Prices Nov. 6.		Business Done Week Ending Nov. 6. Highest.	Lowest.
Anglo-American	59,	½	59	58¾
Do. Preferred	85½,	86	86½	85½
Do. Deferred	33½,	34	33¾	32½
Brazilian ex div.	6 9-16,	11-16	6½	—
Cuba	8,	½	8 3-16	8½
Do. Ten per Cent. Preference	15¼,	¾	15½	—
Direct Spanish	2,	½	—	—
Do. Ten per Cent. Preference	9½,	10	—	—
Direct United States	12½,	13	12¾	12½
Eastern	7¼,	½	7 5-16	7
Do. Six per Cent. Debenture	103,	105	—	—
Do. Five per Cent. do.	98,	100	99½	—
Do. Six per Cent. Preference	10¾,	11½	11½	11
Eastern Extension	7,	¼	7 3-16	6 15-16
Do. Six per Cent. Debenture	104,	106	104½	104½
German Union	7¾,	8¼	—	—
Globe Telegraph and Trust	4 15-16,	5 1-16	5 1-16	5
Do. Six per Cent. Preference	10¼,	¾	10½	10½
Great Northern	7¾,	8	—	—
Indo-European	18½,	19½	19½	19
Mediterranean Extension	2½,	3½	3	—
Do. Eight per Cent. Preference	9,	½	—	—
Reuter's	9½,	10½	—	—
Submarine	215,	220	—	—
West India and Panama ex div.	1¾,	2¼	2 1-16	1 15-16
Do. Six per Cent. Preference	8,	½	8½	8
Western and Brazilian	2½,	3½	3	2½
West. Union Seven per Cent. 1st Mortgage ex div.	108,	112	—	—
Do. Six per Cent. Sterling	100,	102	101	—

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NOTES.

THE HARRISON LIGHT.—We understand that the Sun Electric Light Company has arranged to light the central transept at the Crystal Palace at an early date by means of the Harrison Light.

DYNAMO-ELECTRIC MACHINES.—The cry is, still they come! It would be a great mistake to suppose that we have seen the last of the really important improvements to be made in this direction. The whole question in relation to these machines is at the present moment being very carefully considered by several practical electricians, who have also a due knowledge of electrical theory.

THE RAPIEFF SYSTEM.—A large number of gentlemen met at *The Times* office on Tuesday to see experiments and hear a description of this system. We believe the whole of *The Times* office will ultimately be lighted by this light. A double cylinder engine of about twenty-five horse power is specially devoted to the driving of the Gramme machines, which generate the electricity required by the lamps.

NOVELTY IN TELEGRAPH WIRE.—The National Tube Works, at McKeesport, have succeeded in making a novelty in insulated telegraph wire which bids fair to insure the doing away with the unsightly telegraph poles in the streets of our cities. It consists in rolling an iron tube around a glass tube which insulates one or more copper wires. The new wire is to be used in underground lines in Philadelphia. It is claimed for it that it is better insulated than the ordinary telegraph wire suspended in air, and that, therefore, less battery power will be needed than with the present system. [We greatly question the value of this novelty.]

THE TELEPHONE.—After long study and many experiments, Professor Bell has made an important discovery in connection with the telephone. It is well known that the telephone has been a comparative failure in England on account of the fatal induction generated by the contiguity of other wires. Professor Bell has discovered simple and efficacious means whereby not only is induction prevented, but the clearness and force of the telephonic vocalisation greatly increased. Professor Bell tells me that practical demonstration of the importance of the discovery will be given in London as soon as the necessary preliminaries are complete.—Special Correspondent, *Daily News*.

NON-EXISTENCE OF ELECTRIC ELONGATION.—Edlund, in 1866, and Streinitz, in 1873, concluded that a conductor, when traversed by an electric current, was lengthened in consequence of the electric influence. Wiedemann regarded their experiments as inconclusive, and the question as an open one. Blondlot, by examining the phenomena both in the lateral and in the longitudinal direction, concludes that the phenomena are due entirely to heat, and that the passage of an electrical current in a metallic conductor produces no mechanical effect of lengthening or of shortening. His apparatus was so sensitive that a variation of ·00025mm. would have been sensible.—*Comptes Rendus*.

ANGLO-GERMAN TELEGRAPH.—The German Government has arrived at an agreement with Mr. Patey, the Assistant-Secretary to the General Post Office, regarding the telegraphic traffic between England and Germany. The arrangement was rendered possible by the friendly spirit displayed by the Netherlands and Belgian telegraph administrations and the submarine cable companies concerned in the matter. The convention comes into force on Jan. 1, 1879. Each word of a telegram between Germany and England will cost 30pf., without distinction as to place of origin or destination. There will be no special rate per message, and no restriction as to the minimum number of words that may be sent, no matter by which route the message is transmitted.

VARIATIONS OF TERRESTRIAL MAGNETISM.—M. Quet, starting from the hypothesis of an artificial earth, suitably constructed in regard to the conduction of electricity and magnetism, turning upon its axis and revolving about a sun which diffuses electrical currents, calculates the result which ought to ensue. Applying the general principle of La Place, that the state of a system of bodies becomes periodic when the effect of the primitive conditions of movement has disappeared by the action of resistances, he finds that the diurnal and annual variations, and the opposition in the character of the variations in the northern and southern hemispheres, should all be such as have been actually observed.—*Comptes Rendus*.

"THE TIMES" AND AMERICAN ELECTRICAL WORK.—*The Times* of Wednesday devotes the greater part of a column to the description of various forms of apparatus for the electric light. Among others, it gives prominence to a so-called new light—of course, from America. The ingenious inventor takes a tube, within which he places a thin rod of carbon, surrounding it with an atmosphere of nitrogen, and hermetically seals the tube. There is absolutely nothing new in this. It is well known that, practically, the best method is to use an atmosphere of carbonic monoxide, which may be easily produced by the light itself. We may notice that both forms of lamp have been tried long ago on this side the Atlantic, and, therefore, have no claim to be called new.

THE ELECTRIC LIGHT IN LONDON.—An engineer, writing to the *Echo*, calls attention to the wonderful opportunity which exists in London for thoroughly testing any or all of the new methods of lighting, and of contrasting them with gas. The Royal Albert Hall, South Kensington, one of the largest public rooms in London, is at present lighted by means of 3,000 gas jets, placed in 60 pendants from the roof and main gallery. The capacity of the hall is about five millions of cubic feet; and, as it possesses a double glass ceiling, with great facility of access to every part, either a diffused or a concentrated light could be displayed. For generating the electricity there is ample motive power upon the spot. The boilers are three in number, of 30-horse power each, and there are four engines, one of 30-horse power, two of 12-horse power, and one of 8-horse power, in the engine room. The average consumption of gas for lighting the hall itself during a concert of ordinary duration is, he believes, about 35,000 cubic feet, value, say 7*l*. He thinks that if, one after the other, the proprietors of patented systems of lighting could obtain possession of the hall, we might have a ready means of comparing the power, cost, and properties of the new light, and gain much valuable information. At the present time all our engineers are hurrying off to Paris to see the Place de l'Opéra and a score of other places illuminated by one or other of the newly-invented lamps, and they come back with far fewer reliable statistics than would be gained in a few hours in London if a competitive trial of the above nature were instituted at South Kensington.

GEORGE SAWARD AND TRANSATLANTIC TELEGRAPHY.—The submarine telegraph has now become so completely a fact of everyday life that the public are apt to forget the labours and anxieties which the fathers of submarine telegraphy endured, and the perseverance and scientific skill which were required to bestow this marvellous boon on the social and

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commercial worlds. But, in spite of the oblivion which settles down on the promoters of great works, such as railways or telegraphs, there are, fortunately, certain names so intimately identified with the early history of these enterprises that their very mention recalls, unconsciously perhaps, vague memories of the early days of darkness and difficulty, when it seemed that science would fail, or that the apathy of the public to their own welfare would present an insurmountable obstacle to success. Prominent amongst the names of those to whom we are principally indebted for the benefits of submarine telegraphy is that of the late Mr. George Saward, secretary to the original Atlantic Telegraph Company, whose untiring zeal and extensive knowledge of the principles of telegraphy were so earnestly devoted to the cause of a transatlantic cable. In the course of his long and honourable connection with that and the Anglo-American Company, Mr. Saward had naturally abundant opportunities of collecting the materials for a history of the early days of submarine telegraphy, and it was his intention to have written a work on that subject. His untimely and lamented death, however, prevented him from carrying out this project, to the regret of all who knew how well fitted he was to perform such a task. All the necessary materials for such a work had, however, been brought together, and his son, Mr. Dudley C. Saward, has now, at the request of many old friends of his father, performed the task of arranging his posthumous papers, and editing a work which has just been published, and which will be greatly prized by all who had the pleasure of knowing the late Mr. Saward, as well as by all interested in the subject of submarine telegraphy.

THE TELEPHONE.—Some interesting experiments on electric telephony were conducted on Monday between Norwich and London over a wire 115 miles long, and under the most adverse circumstances of bad weather and powerful induction from neighbouring wires. These experiments had for their object the confirmation of statements that had appeared in the American journals respecting the ability of the carbon telephone, one of Mr. Edison's numerous inventions, and, perhaps, one of the most important, to work over great distances and under conditions fatal to other systems—conditions which, up to the present time, have been the chief obstacle in the practical use of electric-telephony. Messrs. J. and J. Colman, possessing one of the longest private wires in use for commercial purposes in this country, placed it at the disposal of Mr. Edison's representative. This wire stretches from Messrs. Colman's works at Norwich to their office in Cannon-street, a distance of a little over 115 miles. The wire runs on the same poles as the numerous other wires of the Great Eastern Railway, and is carried overhead from the terminus in London to Cannon-street. At 4 o'clock the experiments began, and the incessant crackling and bubbling sounds in the receivers revealed the fact that the adjoining telegraphic wires were at their busiest, and that induction could hardly be worse. Nevertheless, the first exclamation uttered into the hastily adjusted carbon telephone at Norwich was heard perfectly in the counting house at Cannon-street. Conversation then ensued between the two places; some words were at first lost, but after a few simple adjustments conversation was carried on without difficulty, the American accent of Mr. Adams, Mr. Edison's professional assistant, who had charge at the Norwich end, being distinctly recognisable in London. Remarks passed on the weather showed that a storm of sleet was going on at both ends, and the insulation, therefore, almost at its worst. One or two important facts were noticeable in these experiments —namely, that, the adjustments once made, no further change was found necessary, and that conversation was best heard when carried on even a little below the ordinary tone of the voice. Later on, towards nine o'clock in the evening, induction disturbances grew less, but were still considerable; the voices from Norwich were louder, and the individuality of the speakers more marked. Remarkable as these experiments were, they appear to be outstripped by what has been achieved in America through the same instruments. According to a recent work by Mr. Prescott, the carbon telephone has been tried with success over a wire 720 miles in length.

EDISON'S LIGHT.—The *New York Sun* contains the following account of an inteview with Mr. Edison:—"Mr. Edison said that they (the Company) proposed to light the city, public buildings, and private residences with electric lights. The electricity would be made by 20 or more engines, stationed in different parts of the city. Instead of manufacturing all the electricity at one central point, as gas companies make gas, there would be 20 stations. Each station would have an engine and several electric generating agencies. 'You know,' said the professor, 'that when electricity goes out it must always get back to where it went from. Therefore, each station will have one grand return wire, with which separate wires will connect, thus forming the necessary electric circuit. I think that the engines will be powerful enough to furnish light to all houses within a circle of half a mile. We could lay the wires right through the gas pipes, and bring them into the houses. All that will be necessary will be to remove the gas burners and substitute electric burners. The light can be regulated by a screw the same as gas. You may have a bright light or not, just as you wish. You can turn it down or up, just as you please, and can shut it off at any time. No match is needed to light it. You turn the cock, the electric connection is made, the platinum burner catches a proper degree of heat, and there is your light. There is neither blaze nor flame. There is no singing nor flickering. I do not pretend that it will give a much better light than gas, but it will be whiter and steadier than any known light. I do know now that it will be cheaper than gas. It will give no fumes nor smoke. No carbonic acid gas will be thrown off by combustion. It will be a great thing for compositors, engravers, and all forced to work during hot summer nights, for it will throw out hardly any heat. Shades may be used the same as shades upon gaslights, but there will be no real necessity for them. The wind cannot blow it out. There can be no gas explosions, and no one will be suffocated because the electricity is turned on, for it cannot be turned on without lighting the burner. A person may have lamps made with flexible cords, and carry them from one point to another.' 'Can you measure the amount of electricity used?' I asked. 'Well,' Mr. Edison replied, 'I have made no attempt to discover a meter. I know that it can be measured, but it may take some time to find out how. I propose that a man pay so much for so many burners whether he uses them or not. If I find that this works an injustice, why I shall try to get up a meter, but I fear it will be very hard to do it.' Mr. Edison says that electric generating machines could be placed upon steamboats and locomotives, and the boats and cars lighted by the action of the engines, but the instant that the machinery stopped the lights would go out. He thinks that it may be necessary to have an extra engine in each station in cities, to be prepared for accidents. If the first engine should break down, the second one could be used to feed the lights. Country towns, with the use of the electric generating machines, could be lighted by water power. Any power could be used, provided it was strong enough to turn the shaft of the machine with the necessary rapidity."

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THE TRANSMISSION OF LARGE ELECTRIC CURRENTS.

BY J. T. SPRAGUE, M.S.T.E.

This subject is so likely to come prominently forward at an early period, that some of its more important elements call for study. There is, perhaps, no readier means for this than the examination of the suggestions of Mr. Siemens, who, as a leading scientific man, has advocated the transmission to a distance of the natural power of waterfalls, or of the power developed by burning waste coal at the pits mouth, by means of its conversion into electrical energy transmitted by a conductor, and used for producing light or power at considerable distances. In a lecture delivered at Glasgow, 14 March, 1878, and since published, he says:—

"The principal objection that has been raised by electricians to the conveyance of power to the distance of miles is on account of the apparently rapid increase in the size of the conductor required with increase of distance. In order that the magneto-electrical machine may work under the most favourable conditions, it should have an internal resistance depending in a great measure upon the nature of the work to be performed, but not exceeding for quantitative effects 1 ohm or unit of resistance. If the resistance is greater, a notable proportion of the power expended will be converted into heat in the conductors, causing both loss of effect and great inconvenience. By another law the electrical resistance of the circuit exterior to the machine should be somewhat, but not much, larger than the internal resistance, say 1·5 unit. The external resistance is composed of two elements, namely, the conductor, and the resistance of the electric lamp or electro-magnetic engine, which latter may be taken also as amounting to 1 unit, leaving only half a unit available for the conductor. These conditions determine really the size of the conductor for any distance to which the current has to be conveyed.

"Suppose the distance to be half a mile, a copper wire of ·23 inch diameter will produce the half unit resistance, which is already a wire of considerable dimensions, for the purpose of working a single lamp. If the distance be doubled, wire of the same thickness would give twice the electrical resistance, and in order to reduce it again to half a unit, its sectional area must be doubled, so that a conductor of 30 miles length would require to be 60^2=3,600 times the weight of the half-mile conductor, and this enormous increase in weight would certainly be required if the object to be accomplished was the working of one electric lamp by a dynamo-electric machine. My critics have, however, fallen into the error of overlooking the fact that half a unit resistance is the same for a circuit capable of working one lamp as it is for working 100 or 1,000 lamps. Electricity is not conducted upon the conditions appertaining to a pipe conveying a ponderable fluid, the resistance of which increases with the square of the velocity of flow; it is, on the contrary, a matter of indifference what amount of energy is transmitted through an electric conductor; the only limit is imposed by the fact that, in transmitting electric energy, the conductor itself retains a certain amount proportional to that transmitted, which makes its appearance therein in the form of heat."

This heat, as Mr. Siemens goes on to explain, would increase the resistance of the conductor; but to simplify the problem, that heat and its effects are not taken into account in the following remarks; it is assumed that the heat is radiated away or got rid of, so as to keep the conductor at a uniform temperature. But this is a part of the problem which will have to be met in practice.

There are two ways of regarding "resistance":—

1. In Ohm's formulæ it is constant for all currents. *So is the diameter of a pipe transmitting water.* The same pipe will deliver any variable quantity or current of water, corresponding to the pressure; so the same wire will deliver any variable quantity or current of electricity, corresponding to the electromotive force. This aspect of resistance, then, is a mathematical one, existing only in calculations.

2. True, or practical resistance, is measureable by the energy required to overcome it. The energy expended by a current in passing a given conductor (or resistance, resistance in the mathematical sense being simply the reciprocal of the conducting power under unit conditions) varies as the square of the current, or velocity of flow.

Therefore, *electricity is really conducted under precisely the "conditions appertaining to a pipe conveying a ponderable fluid."*

The resistances in a circuit are of several orders:—1. That of the actual conductor itself, which is constant; 2. Any work effected by the current. This may in some cases be expressed as a counter electro-motive force, in others simply as a resistance, but in either case it can be represented in ohms or as a "reduced length;" but the expression of it is variable, because it depends upon the energy expended from moment to moment, and it must be expressed by the square root of that energy in order to assimilate it to the conditions of energy involved in Ohm's formulæ.

When all forms of energy expended are thus expressed as "resistance in ohms," the ratio of useful work done, to the inevitable expenditure in developing and transmitting the energy to the work, is exactly *proportional to the resistances of each part of the circuit.*

There is a difficulty in applying these principles to the illustrations employed by Mr. Siemens, in that we do not know what is meant by the resistance of 1 ohm at the point of work done. If by that is meant simply the wire resistance of an electromotor or of a lamp, these belong to the side of energy lost or expended; if the work to be done is not included in the 1 ohm, then it would seem that, as it would act as an additional resistance, the internal resistance of the generating machine must be increased in order to develop the requisite electro-motive force.

For the present purpose then, which is to indicate the nature of the problem and the difficulties to be met, rather than how to overcome them, Mr. Siemens' actual figures may be taken, and the 1 ohm be assumed as the relative *useful* ratio of the lamp or motor engine.

Here we meet at once the problem, what is the work done in, or the mechanical equivalent of an electric light of say 1,000 candles? Does any one know? The problem involves three simultaneous measures—illuminating power, resistance, and current. With batteries of known electromotive force this can replace the latter data required. We have all sorts of statements, from ·5 to 1 ohm for resistance, to the figures given by Messrs. Ayrton and Perry, p. 269, which I have worked out as follows:—

Groves in series E.M.F. 1·8	Total E.M.F. Volts.	Resistance.			Current Vebers.	Energy in arc. ft. lbs.
		Battery.	Arc.	Total.		
60	108·	12·	12	24	5·33	15,082
80	144·	16·	20·	36	4·	14,157
122	219·6	24·4	30·	54·4	4·04	21,647

Unfortunately, there is no measure of the light produced in these three cases.

For present purposes, I will take the common statement that such a light consumes one-horse power of an engine (though Mr. Siemens states that his smaller size converts two horse power, and gives 1,250 candles) and take the resistance as 1 ohm in the arc and 1·5 in the machine and conductor; this gives $33{,}000 \div \frac{1}{2{\cdot}5} = 13{,}200$ ft. lbs. expended in the arc, a very singular approximation (considering by how different a road it has been reached) to the figures above. The mechanical equivalent of the veber ohm current per second is ·737 foot pound, or 44·24 per minute.

$\frac{13{,}200}{44{\cdot}24} = 298{\cdot}37$, the square root of which 17·273, represents the current developing 13,200 foot-pounds per minute in the ohm resistance, a useful effect of ·4 of the power expended.

If, now, 100 such lights were to be applied to the same circuit conditions, it would be necessary to put in circuit 10 in series, and ten such series in multiple arc to maintain their total joint resistance = 1, and the current would have to be 17·273 × 10 = 172·73, developing 100 times as much heat in machine and conductor, and still expending ·6 of the power in transmission. This also supposes that there is perfect insulation, and no loss on the road, a condition of things not likely to be attained in practice. In converting the current again into mechanical power, the ·4 of power sent would be reduced by the effective ratio of the transforming machine.

In regard to Mr Siemens' "proposal to convey 1,000 horse-power a distance of thirty miles through a conductor three inches in diameter," he says: "The electrical resistance of this conductor would be ·18 of unit, and, supposing that the total resistance in circuit was made 2·5 units, which, as I before stated, gives a favourable working condition, it follows that

$$\frac{\cdot 18}{2{\cdot}5} \times 1{,}000 = 72 \text{ horse-power}$$

would be expended in heating the conductor. This would represent about 15lbs. of coal per hour, a quantity quite insufficient to raise a mass of 1,900 tons of copper, with a surface of 132,000 square feet to a sensibly heated condition."

It seems from this the proposal is not to *convey* 1,000 horse power, but only so much as is possible out of that original power. Then, giving machine 1 and conductor ·18 ohm resistance, we have 1·32 left for useful work; so we divide it:—

1.	Dynamo machine	400	horse power
·18	Conductor	72	,,
1.32	Engine or lights	528	,,

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This latter figure being reduced in actual work to probably 300 at most.

To obtain this 300 horse power, then, we have to provide

1. *X* Machines for converting the electricity into 300 h.p.
2. 1,900 tons of best copper rod carefully insulated.
3. *X* Machines capable of converting 1,000 h.p. into electricity.
4. Appliances and processes for getting rid of 400 horse power worth of heat in this latter machinery.

Mr. Siemens says he is convinced that the sectional area of the conductor might safely be reduced to 2 inches, giving half the weight of conductor; but, as the converting engines would probably cost as much as gas engines of equal power, the question resolves itself into this—is it better worth while to lay down even 950 tons of copper, and fit up the 1,000 h.p. engines, or to purchase the fuel needed to work the 300 h.p. engines where they are to be used? That is a question which might receive different answers in the mountains of Chili, and where coal is to be obtained at even the most extreme English prices.

GENERAL CONSIDERATIONS ON TELEGRAPHIC TARIFFS.*

[CONCLUDED FROM P. 287.]

The Administration has no Right to Claim a Greater Profit Without Increase of Work.—Why so, if the service rendered is greater, and if it is demanded by those who pay? Do not let us forget that all surcharge is, for the administration, a means of giving the ordinary messages at a lower price; that urgency is, moreover, the essential corrective of very reduced tariffs and of the influx which results therefrom. Consider, moreover, what has been said above on the subject of cost price (sec. vii.).

Urgent Telegrams Occupy the Lines to the Detriment of Ordinary Messages Given in Before Them.—If it were so, they would pay the administrations more than sufficient to enable them to devote new lines to the service. But it is not so in Belgium,† it was not so in the ancient Eastern Union which admitted them, neither has it been so from the 1st January, between Belgium and the nine other offices which allow of them, in virtue of the Convention of St. Petersburg, for the first three months furnished a contingent of only 1,328 urgent telegrams out of a traffic of 119,493 messages, being 11 in a thousand.

Supposing some important interest to be involved—a pecuniary one, or even a question of life and death—which requires imperatively an extremely prompt, almost instantaneous communication, the least overflow renders the telegraph powerless to satisfy this interest if the urgent telegram be not admitted. And if it be advanced that all telegrams are urgent, it would be sufficient to look over a hundred to satisfy oneself that the majority of them could undergo a delay of an hour and more without any injury to the correspondents.

With regard to the principle of equality which is pleaded, it is in no way applicable in any public service or in any private transaction, and it is very fortunate that it is so, for equality, in point of fact, even supposing it realised under the most favourable circumstances, could not be imposed on humanity without drying up the source of all effort, all study, all work, and all progress.

The considerations which have just been developed on the subject of the Conference of St. Petersburg have not touched upon any relations with countries not in Europe, those especially which allow of the employment of long submarine lines and the maintenance of high tariffs. These last circumstances have created a peculiar state of affairs, which the Conference had to take into consideration. Agencies have been established in order to express, by means of a pre-arranged language, and within the limits of the 20 words, or even of the 10 words constituting the minimum charge, the contents and addresses of a greater or less number of messages, with a certain economy to the sender, but to the detriment of enterprises which have devoted to telegraph cables a considerable amount of capital. The only way of avoiding this competition, *sui generis*, was the tariff per word, which divides between the telegraph owner and the sender the benefits that the "packing system" brings to those who employ it. In applying the tax per word in this direction, the Conference was not really self-contradictory, for this method was necessitated by exceptional circumstances, and, as it is only applicable to a small number of very costly messages, the complications which it entails remain without any appreciable inconvenience to the offices which have to apply it.

The Conference had no call to place submarine enterprises under the conditional and limited monopoly that we have indicated (III.). Like its predecessors, it was anxious to maintain the equality of tariffs and to shield these enterprises from the injurious effects of unlimited competition, and, at the same time, to insure the interests of the public.

On the whole, the resolutions taken seem to us to be conformable to the rules that we have deduced, and of a nature to justify the telegraphic monopoly of the European states (I. and II). The international tariff has been maintained, on the whole, in order to preserve to the telegraph offices the resources of which they have need (IV., V., VI.), and it is, as a rule, superior to the internal tariffs (VII.). Novel measures have secured to the public certain advantages without compromising these resources, and by proportioning the service rendered. Differences in the charge according as there are more or less States included in the operations cannot be avoided (VIII). If, in certain directions there should be some overcharge, the general convention permits these to be remedied by particular arrangements agreed upon between the parties interested. In such cases, in which it may be necessary to revise and correct at need the method of distribution of and the produce of the taxes amongst them, it would be advisable to ascertain, in the first place, what is the proportion of the cost price (VII.) between countries of different extent, taking care to ground this study upon a fair basis, applying to it the same coefficients, and deducting expenses which are not connected with international relations.

As we stated before laying down our eight questions, we do not pretend to have solved them infallibly and definitively. We have formulated and written beneath them figures and facts. It is the first stone which brings others into requisition not for the immediate purpose of building, but with the object of preparing and prudently bringing together with care the materials for reconstruction, so far as it may be necessary to reconstruct.

T. VINCHENT,
Inspector-General of the Department of Public Works of Belgium.

* Translated from the *Journal Télégraphique*.

† We have pointed out, at the beginning, 37,636 telegrams exchanged in the interior of Belgium, that is to say less than 2 per cent. We do not include 6,687 night telegrams, because for the latter urgency and the surcharge are obligatory, and they cannot be accused of impeding the other messages, since there are none.

CAPITAL ON GAS WORKS AND SHARES.

BY THOMAS T. P. BRUCE WARREN.

Statements have been made during the past few weeks respecting the amount of money sunk in gas properties, and it seems desirable that something should be given to show how the sum is arrived at.

In an article in the *Standard*, the figure is taken at 100,000,000*l.*, but the figure given by the gas authorities is fixed much higher. At the meeting of the British Association of Gas Managers, held at Leeds, the chairman, Mr. J. Paterson, is reported to have said "that the gas manufacture was one of the more important industries of the day, no less than 130,000,000*l.* being invested in it." We are interested to know how these figures are made up. It is not easy to see why the figures should be exaggerated, unless it is to endeavour to create a counter scare to the electric light, which must make the shareholders more reckless in getting rid of their property, or to excite some sympathy. We are sure every good-hearted Englishman will deeply sympathise with those poor clergymen, widows, and maiden ladies, whose "little all" is locked up in gas securities; we should advise them to keep cool under the present circumstances, for, although the shares themselves may not be worth perhaps what was paid for them, the income from the investment cannot for some time to come be very seriously diminished.

The authorised capital of the six metropolitan companies is, say, about twelve millions. Now, London contains one-eighth of the total population of the United Kingdom, and $12 \times 8 = 96{,}000{,}000$. This is the uncertain calculation, which gives us 100,000,000*l.* Now, if we correct some of these mistakes, as given in the *Standard*, and use the total authorised capital which had been paid up and borrowed, and get the ratio of population between London and the United Kingdom, we shall be nearer the figures given by Mr. Paterson.

We question the accuracy of the figures obtained in this way. To assume that the consumption of gas is in direct proportion to the population seems to us very presumptive, and to apply the reasoning with the metropolis as the unit of comparison is preposterous.

The total assessment for all the gas companies in the United

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Kingdom for the financial year ending March 31, 1877, is 3,030,192*l*., and, dissected, reads as follows:—

Metropolis	£1,003,512
Rest of England	1,715,046
Scotland	214,340
Ireland	97,264
Total	£3,030,192

Now, if we distribute this 3,000,000 over a capital, &c., of 100,000,000*l*., we are perplexed to find how gas ever became so favourable a field of investment. The fact is that the reasoning upon which 130,000,000*l*. or 100,000,000*l*. is given will not bear the handling of criticism.

We shall now endeavour to show how we make the total capital invested come to very much less.

Let us assume that on the average this sum of 3,000,000*l*. represents a profit of 10 per cent. all round on the different descriptions of property; some principal companies pay more and few pay less, and the Metropolitan Companies pay about 7 on their ordinary stock. This will give about 30,000,000*l*. We had roughly fixed the figure at 40,000,000*l*.

Whatever it might be, a further analysis of the development of gas in the United Kingdom during the year ending as above must make the matter more unpalatable to the shareholders.

The total number of assessments for gas companies in the United Kingdom is given as 1,491 over the preceding year:—

Metropolis	17
Rest of England	1,089
Scotland	279
Ireland	106

The year 1877 was favourable to gas proprietors, notwithstanding the great depression in general trade.

The increase in assessment for 1877 over 1876 is as follows:—

England ...	£333,001 = 14	per cent. increase.
Scotland ...	24,000 = 12·6	,, ,,
Ireland......	44,000 = 83·0	,, ,,

Well may our friends in Cork tremble at the thought of the electric light.

THE AGOPHONE.

The Cincinnati *Gazette*, speaking of the Agophone, says:—

One of the defects of Edison's telephone, with its complexities of electric battery, disks, and mouth and ear tubes, is in its inability to receive other sounds than those uttered directly into the mouth-piece, or emit those carried with sufficient force to be heard again at a greater distance than an inch or two from the ear tube. This defect was partly remedied in the invention of the microphone, an instrument which magnifies sound. The whole is very complicated, however, and fails to reproduce sounds in their original strength of volume, or to receive sounds which are not especially directed against the disk of the receiving instrument.

It is not a little strange that the only important improvement upon the telephone, by which sounds uttered at large in a room can be gathered up, transmitted, and as loudly diffused again, should have been perfected in a country village by men who make no pretensions whatever as scientists. The professor takes the longest way around, and the schoolboy finds the shortest way home.

When the reporter entered the "curiosity shop" of the Messrs. Jewett, at St. Omer, Ind., he found a group of neighbours gathered in the store listening to a conversation between the elder Jewett in the store and his wife at their residence on the hill, a quarter of a mile away. Mr. Jewett was leaning against the edge of the counter, three or four feet in front of a little instrument attached to the case of post-office boxes, and which seemed to be nothing more than a square wooden box, the front end open, and the rear connected with a fine wire running through the window. He spoke in a natural and easy tone, apparently directing his words to some other object than the instrument. The replies came back with such distinctness that they were understood equally as well in the furthest corner of the store as at the mouth of the instrument. Mr. Jewett then asked Mrs. Jewett to sing, and the words of the pretty hymn, "Over there," filled the room. The only difference apparent between the tone as heard and the original was that it seemed to have been uttered in an adjoining room, through an open door. Mr. Jewett afterward went up home, and, by request of his son, took a seat about eight feet distant from the agophone, and played the "Arkansas Traveller" on his violin. Every note was distinctly heard on the street ten or fifteen feet in front of the drug store, and in the rear yard which was separated by another room from the drug store. Mrs. Jewett then played an air on an organ, standing back of the agophone eight or ten feet, and every note was heard by all in the drug store with equal distinctness. For a surprise to Mrs. Jewett she was asked to listen, and a lighted firecracker was placed in the box of the instrument. When it exploded the laughing of the inmates of the house was distinctly heard. "Did you hear anything?" was the query from the store. "I should think I did!" was the reply. "This is'nt the Fourth of July!" A lazy boy was then sent up to the house with half a dozen firecrackers to experiment with there, and the lazy boy picked up another lazy boy on the way and proceeded to the house. When they reached the house the party in the drug store heard the door close upon them, the conversation between the three as to the purpose of the errand, the footsteps upon the floor as the boy proceeded to the instrument, and then the explosion, almost as loud as that occurring in the drug store. Then the character of the exhibition was changed, and Mrs. Jewett was heard sweeping the floor. A whispered conversation was then carried on, the speaker in the drug store standing about two feet in front of the instrument, and the replies were distinctly heard. A watch placed in the box was heard ticking at the other end. Other experiments show that sound was transmitted equally well when diffused through a number of terminal instruments.

An examination of the instrument itself revealed nothing to indicate its peculiar power to gather up sounds, carry and diffuse them. The receiver is a mere wooden box, about the size of a cigar box cut in two. The open front is adorned with a narrow border of gilt frame, the sides are of black walnut, the back of thin iron plate. About an inch forward of the iron plate, and filling up the sides of the box, is a disc or sounding board of white pine, with an opening about an inch in diameter in the center. From the center of this opening a small funnel of copper plate extends back through the sheet iron plate, and an inch or so beyond, where it receives and fits closely around a thin brass wire. About two yards of brass wire are used at either end of the line, the intermediate connection being of copper wire. Mr. Jewett calls this funnel—but improperly, it may be said—the "vibrator." If there be any vibrator about the agophone, it is probably the whole wire. There may be some secret, which the inventor is disposed to conceal, in the construction of the box, but it is more probable that the successful working is due more to the perfect conductive power of the combination of metals in the wires and the radiating power of the box. Whatever it is, the inventor will keep it to himself until the arrival, at least, of his letters patent. So far as experiments have gone, this agophone is a vast improvement upon the telephone. The only difference between its operation on the short, and that on the longer wire, appeared to be that on the shorter the vibrations of sound were closer together, and, therefore, less distinct. On the longer wire they were more regular, and seemed to be transmitted with greater naturalness. The Messrs. Jewett are preparing to extend a line from their drug store down to St. Paul. This will give a better test than has been made so far, but the capacity of the instrument for transmitting sounds great distances without the aid of electricity remains to be proven.

CORRESPONDENCE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: My object in writing this letter is to point out a grave discrepancy, which I have no doubt has been noticed by many of your readers. It is this:—The committee appointed by the Franklin Institute to make careful experiments with the various dynamo-electric machines having completed their duty, sent in their report, which was given in your columns in several of the early numbers.

Tables are given showing the comparative value of the different machines. Take the Gramme machine. The report states that with a horse-power of 1·84 a light equal to 705 standard candles is produced. Now, here comes the discrepancy. In Mr. J. N. Shoolbred's paper, read before the British Association, it is stated that with the *same* machine (viz., the A size) a light equal to 6,000 candles is obtained with an expenditure of only 2½-horse power; it is also stated that, with a much smaller machine, and an expenditure of only 1½-horse power, a light equal to 2,000 standard candles is produced. The state of things, then, is this. The Committee of the Franklin Institute, with an expenditure of 1·84 horse power, only obtains 705 candles, whereas Mr. Shoolbred states that with an expenditure of 1·5 horse power 2,000 candles can be obtained. I should be glad to know the views of some other of your readers on this subject, as it is rather important to find out how such a discrepancy as the one I have mentioned should have occurred.—I am, &c.,

A. C. M. WEAVER.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

We cannot undertake to return drawings or manuscripts, and must, therefore, request Correspondents to keep copies.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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Quarterly	4s. 10d.
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NOTICE TO EDITORS.

We shall be happy to exchange with the Editors of Scientific journals who receive the first numbers of THE ELECTRICIAN.

Nous serons heureux de faire l'échange avec Messieurs les Rédacteurs des Journaux scientifiques qui recevront les premiers numéros de L'ELECTRICIAN.

Es wird uns ein Vergnügen sein mit den löblichen Redactionen der deutschen und anderen continentalen Journäle und Zeitschriften, denen die ersten Nos. des ELECTRICIAN *zu Händen kommen möchten auszutauschen.*

I Signori Editori di giornali scientifici che riceveranno i primi numeri dell' ELECTRICIAN *ci faranno cosa gradita accettando il cambio che loro offriamo.*

TITLE PAGE AND INDEX.

The Title Page and Index for our First Volume, which is complete with this number, will be ready for issue next week.

THE TECHNICAL EDUCATION OF TELEGRAPH ENGINEERS.

In several previous numbers we have been considering the education of Electrical Engineers, and we have advocated the advisability of some organised system of training being started under the superintendence of the Society of Telegraph Engineers, in consequence of the facilities offered at the present time at the existing colleges being, we think, inadequate for imparting a technical education; and we took as an example one of the several colleges where a good general electrical education was given, and noticed shortly some of the points in which its course fell short of a complete electrical training. We now learn that our remarks have been regarded by some as implying that the education in physics offered by the British colleges was incomplete. This erroneous impression, we think, must have been caused by a slight confusion that appears to exist in the minds of some between two totally distinct questions—the one, should technical education (in our particular case the technical education of a Telegraph Engineer) be given at colleges; the other, are the means already existing at these places of instruction adequate for imparting such an education? Some people, starting, unconsciously, perhaps, with the conclusion that the real technical education of an engineer must be obtained after he leaves college, are naturally led to the result that the present collegiate system supplies all that is required. Hence, when any question is mooted regarding the technical training of telegraph engineers that might be imparted at a college, they are inclined to remark, "Oh! but colleges already give all that is necessary," forgetting that the necessity refers not to general scientific education but to technical training.

So far from imagining that students of natural philosophy are unable to obtain a good general knowledge in electricity, we feel sure that the present system of teaching, and especially of practical teaching in physical laboratories, which during the last few years has been so strongly urged forward in our colleges, must supply the means for their being able to obtain a solid groundwork, just as it supplies the means for their being able to obtain a good knowledge in optics or in any other branch of physics. But no college course, as far as we are aware, professes to turn out opticians—we do not mean simply men who can answer questions about spherical or chromatic aberration, and pass a creditable examination in Airy's or Parkinson's Optics, but men who know really how telescopes are made—not examination-paper telescopes, but telescopes used in observatories—men who would be of practical value say in Chance's glass-works or in Browning's mirror-polishing room. Why, then, should a college profess, with its present means, to turn out a Telegraph Engineer? Full-blown doctors, we know, step forth from Universities, but it must be remembered how large a portion the hospital work, the clinical practice, has played in their education. In fact, when the University education of electricians is as complete as that of doctors we shall rest satisfied.

Perhaps, we can best explain what we understand by the education of a Telegraph Engineer by mentioning one or two of the things we should expect such an education to give beyond what is learnt by an ordinary student. We should expect them both to know how to calibrate a galvanometer, to measure resistances, electromotive forces of batteries, &c., to know the general principle of determining the position of a fault in a telegraph line, but we should not expect the ordinary student to know exactly what is the best test to apply in each particular case to find out the position of a polarised fault in a submarine cable; we should not require the general student to be really expert in jointing the cores of cables (an operation of no little difficulty, and one almost impossible to teach to workmen, unless one can do it well oneself); we should be satisfied if an ordinary student knew the general principles of struts and stays; but we should require a telegraphic student to learn to be able to put up a line with certainty, so that the stress on every insulator was the same. It would be, perhaps, sufficient if the Natural Philosophy class knew that holes were dug in the ground for telegraph posts; the telegraph student, however, should have decided opinions about the use of earth-borers for poles, when they should be used, and when not. A knowledge of how it is that a Bell's telephone transmits the character of the sound, as well as the number of vibrations, would be enough, perhaps, for the ordinary student; but it would be desirable that the student of telegraphy should be taught to consider whether the telephone is of real use for commercial, or merely for private messages, and should be so trained that he would not make the mistake into which the German Post-Master General recently fell of imagining that Bell's telephone could replace the instruments in ordinary use with telegraph administrations.

We will now say a word or two about the first question: Should telegraphing engineering be studied at colleges? This question naturally divides itself into two heads. First, are they suitable places; second, is there a demand for such instruction?

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That they are adapted for teaching telegraphy cannot well be doubted, seeing that, although the ordinary physical laboratory and course of natural philosophy would have to be much extended before they could be said to comprise any form of technical education, still, there already exists at colleges, both in the form of apparatus and sound training in physics and chemistry, much that is needed in educating a Telegraph Engineer. So that, if the colleges would only grasp what is really required of them, we should not for a moment contend that a distinct educating staff, under the guidance of the Society of Telegraph Engineers, is a requirement. Possibly, the governing bodies of our universities are influenced by the second consideration, and are inclined to think there is no demand for telegraph engineers. We might content ourselves by replying that, considering that the doctors are, many of them, beginning to view with dismay the possibility of their scanty crusts being snatched from them by their more able female co-operators, and the young lawyers have to turn to literature rather than to law to earn their bread, there is at least as good an opening for telegraph engineers as for a doctor or a barrister; but we are able to do something more than hold out to students of electricity the pittance of a briefless barrister.

It may, perhaps, somewhat astonish our readers if we take up the view that electric engineering is yet but in its infancy, or, at any rate, is but the young boy just going to school, and that the manhood of this science, the giant that it will grow into, has yet to come. Let us consider what are the two great desiderata in telegraphy at the present moment: they are probably signalling through bare submarine wires, and an incomparably more rapid system of automatic sending than is at present employed on land lines. The method of solving the first problem is shadowed forth, perhaps, in an article on "Electrolytic Polarisation" in Nos. 15 and 16 of the *Journal of the Society of Telegraph Engineers*, but before the complete solution is arrived at much experimental work will be necessary. At the Philadelphia Exhibition the English jurors were astonished to see some eleven hundred words transmitted per minute with a modified Bain's instrument. Now, however, *treble* that speed has been accomplished in America on a line some three hundred miles long, and, what is more, abandoned as too slow. And why too slow? Because it is seen clearly that a perfect "fac-simile instrument" by means of which the entire written letter of the sender can be instantaneously reproduced at the distant station, is the telegraph of the future.

From which nation will these inventions spring? We have heard a good deal lately about inventive talent flourishing as well here as on the other side of the Atlantic; but the arrival from America of one vague telegram regarding the electric light makes every English electrical firm rush to the Patent Office and patent something, and every gas shareholder tremble in his shoes; and the public here talk glibly about the divisibility of the electric light without paying the slightest attention (so widespread and general is our electrical education in England) to the simple fact that the heat generated in an electric circuit is proportional to the product of the *square* of the current into the resistance; so that, if a given total quantity of light be produced with one hundred lamps, it is about one hundred times as expensive as if it were produced all in one lamp.*

In rapid succession we have received Bell's telephone, Edison's carbon telephone, the phonograph, the tasimeter, the "electric light scare," and now, but a few days back, a non-magnetic receiving telephone to be used with the carbon transmitter.† Is every invention in telegraphy to proceed from the United States? Let those answer this question who think there is no field for highly-trained Electrical Engineers.

* Let there be a very economical battery, or one in which the resistance is very small, so that there is little internal heating or loss of energy; and let this battery be employed in sending a current c through a lamp of resistance l, then the heat generated per second, and, therefore, approximately the light will be proportional to $C^2 l$, and the cost per hour to nC, where n represents the number of cells in series. Now, let there be m lamps in parallel circuit, all of the same resistance l as before, then the total resistance will remain the same, and, therefore, the total current as well as the cost per hour; but the current now passing through each lamp will be $\frac{C}{m}$; therefore, the heat generated per second in each lamp will be proportional to $\frac{C^2}{m^2}$. Consequently, the total light given out by all the lamps will be proportional to $m\frac{C^2}{m^2}$ or only $\frac{1}{m}$th of the light in the previous case. The equations become more complicated if we introduce the condition met with in actual practice—viz., that the resistance of the light is a function of the current passing through it (see the paper on "The Resistance of the Arc of the Electric Light," on p. 268, in our issue for Oct. 26); but the general principle remains the same that it is much more expensive to produce a given amount of light with a number of lamps than with one lamp only; hence it is that the enormous pecuniary saving effected by using the electric light vanishes when we attempt to subdivide it.

† Report of the meeting of the Physical Society on Saturday, the 9th instant.

LITERATURE.

THE TELEGRAM CODE.

The Telegram Code. By Dr. G. Ager, 144, Gresham House, Bishopsgate-street, E.C.

We have to announce the issue of the second edition of "The Telegram Code." This work is so well known and appreciated by telegraphers that it is not necessary to enlarge upon its merits. We may, however, state that whilst the author has preserved intact the plan of the first edition, he has taken advantage of the opportunity afforded by a reprint to extend its several parts very considerably, and also to make some very useful additions. The most noteworthy are the "Quotations by Tibbs," that afford facilities for telegraphing three exchanges, &c., in one word, which word also serves as an indicator that the word or words following it report the more important market changes of four articles per word. If we mistake not, many merchants will welcome a code that renders them entirely independent of telegram agencies for prompt and reliable market reports. As a general code must necessarily go outside the wants of many telegraphers, we think the author has done wisely in providing interleaved copies, so that the code words in any such parts may be utilised for any objects of more special interest to the parties using it.

Respecting the all-important matter of code words, it will be sufficient to state that the author has received from the managing director of the Eastern Telegraph Company a letter to the effect that the "Telegraphic Code" submitted to him appears to him and to the experts in the service to be satisfactory in the respect that words telegraphically unsuitable have been carefully eliminated. The words averaging seven letters, and having a good deal of simplicity in their character, are features which recommend them to his judgment as generally suitable for exact transmission.

TELEPHONES AND PHONOGRAPHS.

Telephones and Phonographs. By A. Niaudet, C.E. J. Baudry, 15, Rue de Saint-Pères, Paris.

If an Englishman or an Englishwoman desires information on certain subjects which have created a considerable amount of excitement in the scientific world, or on the work of certain inventors which the French Government thinks deserves the Cross of the Legion of Honour, and asks for a book on the subject at any library, he or she is politely informed that no Englishman has thought it worth while to write or publisher to get written such a work. Whilst, therefore, we cannot speak of

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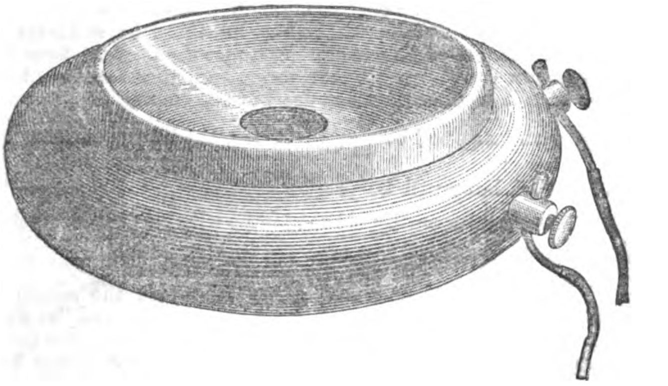
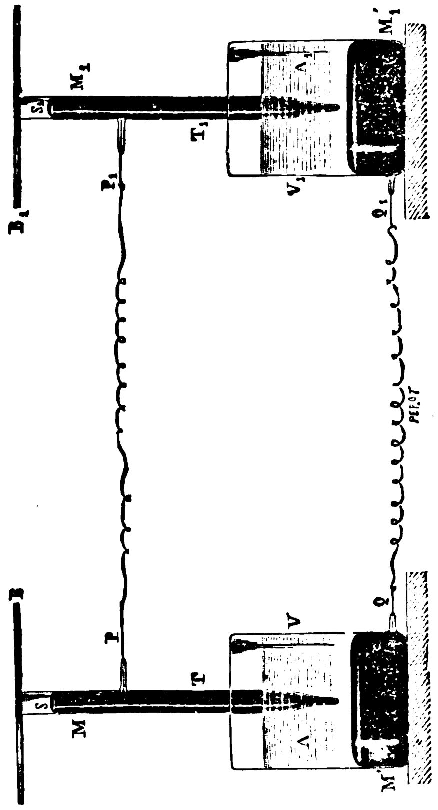
any English work, the only course is to call attention to American and French books on these subjects. The work before us is from the pen of one of the ablest electricians of France, and one who has previously performed good work with his pen. In this book, the author first describes the various means hitherto adopted for transmitting sounds, and especially vocal sounds, to a distance, and also a brief account of the theory of sound. He then proceeds to discuss the work of Reiss, the pioneer of telephone discovery, and of Bell; the latter, indeed, occupies a large portion of the work. We find a clear and graphic illustrated



description of the instrument, the theory of its action, and a chapter devoted to its application. It is shown how the telephone can be employed for domestic purposes, in commercial pursuits, for military and naval purposes, as well as in purely scientific investigations. We cannot better give our readers an idea of the value of this work than by quoting the author's words. He thus describes the watch telephone (pp. 84-5) :—" L'appareil représenté en vraie grandeur par la figure 11 est la forme la plus réduite du téléphone qui ait encore été réalisée. Nous avons donné à l'aimant la forme en limaçon et nous l'avons placé dans



un plan parallèle à celui de la membrane. L'audition est aussi nette avec cet appareil* malgrè son petit volume, qu'avec les téléphones à main ordinaires. L'appareil peut facilement être mis dans la poche et sa forme justifie le nom qui nous lui donnons." Particular attention is directed to the telephonic work of Mr. Cromwell Varley, which has to a certain extent been overlooked, probably because that able electrician has not been quite so successful as Bell. The author says that Mr. Varley indicates several means by which vibrating currents can be produced :— " Son appareil comprend un diapason dont une des branches porte un appendice qui envoie le courant d'une pile unique alternativement dans deux fils distincts. Ces deux fils sont enroulés en sens inverse sur un noyau composé de fils de fer doux ; ce sont de courants inducteurs d'un bobine d'induction, un troisiéme fil enroulé par-dessus est le fil induit de cet appareil, et les courants qui y prennent naissance, et qui sont alternativement en sens inverse, sont envoyés sur la ligne." The preceding figure illustrates the mercury telephone of Mr. Antoine Bréguet :—

We must refer readers interested in these subjects, and their name is legion, to the book itself for description, and much valuable information, on the microphones of Hughes and of Edison, the phonograph of the latter, experiments of Kænig, Rosapelly, Jenkin and Ewing, Cornu and Mercadier. Altogether, in the space of 170 pages we have a good example of those works for which France is famous, and which it seems we must contentedly admire, without seeing them rivalled by anything similar on this side the Channel. Ganot's physics, also Deschanel's, have been among other works of a similar nature translated, and it may be that some day an English translation of the work before us will appear.

* We are indebted to the author for the accompanying illustrations.

ELECTRIC LIGHTING.

*On the Present State of Electric Lighting.**

By J. N. Shoolbred, B.A., Mem. Inst. C.E

(concluded from page 299.)

Lamps or Regulators.—The duty to be performed by these small apparatus is of a very important, delicate, and complicated character; so important, that unless the regulator fully complies constantly and continuously with the conditions imposed upon it, it completely stultifies the regular supply of the electric current which a machine of excellent quality may supply to it. Amongst the duties which these apparatus are expected to perform are :—

1. The regular and gradual approach of the carbons according to rate of combustion; and, therefore, a progress varying not merely with the strength of the current, but also with the nature of the supply, whether in one continuous direction or whether alternating in direction.

2. The approach or separation of the carbon points to create the electric spark in the first instance, and then to counteract the ever-varying irregularities of the strength and supply of the current during the period of illumination; and also to prevent these irregularities being felt beyond the lamp itself (a most important and essential point where several lights exist on one circuit).

3. The normal separation of the carbons according to the desired length of the voltaic arc, which is deemed suitable to the strength of the current employed.

The first-named duty is generally performed, in most apparatus, either partly or wholly by gravity, which necessitates the carbons being placed over one another. In some of the most recent forms, however, the carbons can be placed horizontally, or in any other position, and either in a direct line opposed to each other, or inclined towards one another, their approach being performed by mechanical action. The second set of duties are carried out almost universally by means of electro-magnets and armatures, &c., contained generally in the base of the apparatus. The third duty is performed ordinarily by adjustment screws placed on the attachment of the carbon holders, and which can be made to raise or depress the carbons at will even during the period of illumination. Of the earlier forms of lamp, the most ingenious, those of Dubosco and of Foucault, have gradually given way to that of Serrin, which is, perhaps, at present, the most in use, where single lights only are desired from a machine. In it the carbons are placed vertically over one another, the upper carbon being made to travel by means of a rack and pinion attached to the bottom of its holder, and driven by a spring which is controlled by an electro-magnet placed in the base of the lamp. This electro-magnet, according to the force of the current passing into it from the main current, also attracts or rejects an armature, the effect of this oscillating movement being to cause the lower carbon holder to rise or fall, according to the irregularities in the strength of the main current, which is itself producing the voltaic arc. The normal separation of the carbon points, to suit any required length of arc, is effected by raising or depressing the upper carbon holder, by means of the screw placed at the top of its upright where the horizontal arm is hinged.

* Read before Section G of the British Association: Dublin meeting.

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The Jablochkoff Regulator or "Candle."—A "candle" consists of two cylindrical sticks of the carbon ordinarily in use for electric lighting, each about 3-16in. in diameter and 10in. long; they are placed vertically alongside of one another, with a space of 3-16in. between them. This interval is filled in with plaster of paris (sulphate of lime), though at first kaolin, or China clay, was used for the purpose.

M. Jablochkoff's idea in this arrangement was evidently a desire to dispense with the delicate mechanism in use in the ordinary regulator (such as in the Serrin just described), in order to keep the carbon points sufficiently near to one another to allow of the voltaic arc being properly formed between them. This he effects by placing the two carbons alongside of one another, but with an insulating substance between them, and at a distance sufficient to prevent the electric spark passing directly from one carbon to the other.

Before lighting there is laid horizontally on the top of the candle across the plaster a small bit of carbon to lead the electric current from one carbon to the other. During combustion this communication is kept up by the gradual fusion of the insulating layer, as the carbons burn downwards. This necessarily involves a considerable loss of electric force, probably quite 30 per cent., which, with the ordinary arrangement of the carbon points opposite to one another, would all be utilised in augmenting the intensity of the voltaic arc. Should the light, however, through any irregularity in the current, be extinguished after it has been lit, there is no re-lighting the candle without replacing a fresh piece of carbon on the top surface.

A very serious objection to these candles is the shortness of their duration, only one and a half hours on an average. It is true that the bottom plate of the lamp carries usually a supply of four candles (and which number may be increased), and that these are arranged so that the current may be deviated from the burnt candle to a fresh one. Although an automatic arrangement to effect this object has, it is said, been devised, yet, so far (at the date of the preparation of this paper), in the street lighting in Paris the change has been effected by hand.

The quality and steadiness of the light produced from the candles leaves much to be desired. For, besides the irregularities in the flame introduced by the want of uniformity in the composition of the carbons (which it is the present object of their manufacturers to minimise), there are added those consequent upon the volatilisation of the insulating layer of plaster of paris. This last, moreover, from its chemical composition, introduces from time to time, into the otherwise pure flame, rushes of a red colour, which vary much in intensity and duration.

The Lontin Regulators.—In the early stages, M. Lontin made use of the Serrin lamp, and, indeed, he does so largely still in certain cases, with a very ingenious modification (if not, indeed, a radical alteration) of his own to adapt this form of lamp to circuits where more than one light was used, so as to prevent the irregularities of any one lamp extending to any others which might be placed after it on the circuit. The change, though slight in appearance, is so great that it actually inverts the action of this delicate portion of the Serrin apparatus in its original, interrupting the current where there was previously admission, and *vice versâ*.

M. Lontin has latterly introduced two forms of regulator, which have the two advantages of being independent of any particular position (the action of gravity being entirely dispensed with), and of allowing any length of carbon being used, and of providing, therefore, for any ordinary period of illumination without the necessity of a fresh supply of carbons. In one of these regulators the travel of the carbons is effected by means of two endless screws with threads in opposite directions, one to each carbon holder, which are thus caused to progress; the action of an electro-magnet causes these screws to revolve when required to do so. In the other regulator an electro-magnet causes a round bar to revolve which runs lengthwise with the carbons, which motion is imparted by means of bevelled gearing to small wheels, at the extremity of which the carbon-holders revolve, and so propels the carbons gradually forward. These carbon holders are fixed at about 2in. from the carbon point, and the resistance which each current has to encounter is limited, therefore, to that due to this length, irrespective of that of the carbon.

The Rapieff Regulator.—In *The Times* of June 3rd last there was an article which gave a general idea of this method of producing a number of lights from a single electric source, and which pointed out a few of the peculiarities and advantages arrived at by this system.

Since that time these features have been further improved upon and added to; and, as they possess several interesting points, some of which may be peculiar to the system, it seems not out of place to attempt to describe some of them here, even though the light has not yet been publicly applied to illuminating purposes, though this, it is stated, will only be delayed but a few weeks.

The electric current is at present supplied from the Gramme "generating" machine, which gives off its current in one continuous direction. This in itself is an interesting feature, this form of machine having hitherto been used to supply a single light, or else as the "generator" of the current supplied, as already described in the Jablochkoff candle arrangement, to the second or "distributing" Gramme machine. Furthermore, in both the Lontin and the Jablochkoff systems the divisibility of the electric light is effected with the currents produced in alternate directions; whereas M. Rapieff deals with the primarily created continuous direction currents, thereby dispensing with the use of the second or "distributing" machine. M. Lontin, some time ago, it should be added, distinctly stated that, though possible to make use of the continuous direction current for a number of lights, he preferred the alternating ones, as he has hitherto made use of in his system.

It is, however, at present at least, in the lamp of the regulating apparatus that the most salient and original features of the Rapieff system occur.

The vertical arrangement of the carbons is retained in this regulator; but each carbon is, as it were, split in two lengthwise, and the halves placed relatively to each other in the form of a V, approaching each other only at the point of illumination. Any one of the carbons, it may be urged, may thus be removed for renewal without extinguishing or interrupting the light.

Each of the carbons passes through a holder, with a small guiding wheel, at a point about 2in. from the luminous point, whatever the entire length of the carbon. As it is at this point that the electric current enters the carbon, the total resistance the former experiences in its passage to the luminous point is due to the intervening 2in. of carbon only, irrespective of the entire length of the latter. This resistance is therefore uniform throughout the entire time of combustion. This last advantage is likewise shared, as already seen, by the "horizontal" regulator of M. Lontin, where each carbon is gripped at a short distance from the luminous point, and independent of the length of the carbon.

The gradual progression of the carbons towards the luminous point, as required by the rate of combustion, is effected solely by the intervention of gravity. A small dead weight works up and down on the two vertical guide rods, from which the jaws carrying the carbons are made to project. The weight is connected by thin cords, working over small pulleys, with the end of each of the four carbons, and tends constantly to urge them towards the luminous point, the actual vertical distance by which the upper and the lower pair of carbons shall be separated being adjusted to the required length of the voltaic arc by means of a screw fixed on the hinder part of each jaw which carries each pair of carbons, raising or depressing it vertically. This adjustment can of course be made, whenever required, during illumination, according to the strength of the electric current.

In almost all forms of regulators it has been found necessary to introduce some automatic arrangement, generally by means of an electro-magnet, or a coil placed in the bottom of the apparatus, to compensate any irregularities in the strength of the electric current, and to separate the carbon points in accordance with it. Nor is an automatic arrangement of this nature wanting in the Rapieff regulator, to cause the necessary closing up of the carbons to produce lighting. The two thin flat bars of an electro-magnet, placed horizontally over one another, are able, by reason of the play or spring in them, to approach each other more or less at one extremity, in keeping with the variations in the current. This movement is communicated by means of a lever to one of the vertical guide rods, carrying the jaw of one pair of carbons, which latter are thus made to correspond to the vertical movements of the electro-magnet.

Connected with this part of the apparatus is one of the most interesting features of the system; it has been termed by M. Rapieff a "safety apparatus," the object being to have a second light in reserve, which shall be automatically set alight by the current, if the first one should from any cause be extinguished. To effect this, there is placed in front of the pliable ends of the above-mentioned electro-magnets an armature with an opposing spring, which latter withdraws the armature from the electro-magnets as soon as the current ceases to pass into them. This pivoting action of the armature causes a corresponding up-and-down movement in a piece of wire, which forms the end of a branch connection, and which leaves the main circuit wire a short distance before the latter communicates with the carbons and the electro-magnets just described. As long as the armature is kept by the current pressed against the electro-magnets, the end of the wire is kept suspended in the air; but the removal of the armature by the action of the spring causes the wire end to descend upon a metal plate which is in

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direct communication with the second or reserve lamp. The latter is, therefore, when required, placed automatically into communication with the main wire, through the interruption of the current in the first lamp, causing thereby the release of the armature and the descent of the wire end upon the contact plate.

An apparatus termed a "shunt," having a similar obect, is attached to the Siemens machine, where required, as in lighthouse illumination, to enkindle a reserve light, which is always kept in readiness.

CARBONS.—Though different substances have been made use of as the points between which the voltaic arc is produced, yet, in actual practice, small sticks of carbon, either cylindrical or rectangular, are universally used. They vary in diameter between from 3-16 in. to nearly 1 in.; probably, about ⅜ in. is the size most generally employed with the power of the lights made use of for industrial purposes. Their exact diameter should be proportioned to the strength of the current employed. The nature of the carbon point formed during combustion will soon show whether the due proportion is observed or not. A long tapering point should be corrected by a large carbon, while a blunt flat-headed one indicates an excess of the combustible, at least with alternating direction currents.

The carbons are composed of the material (graphite) which is deposited on the inside of gas retorts. For some time this was simply cut and shaped out of this substance in its natural state. Latterly, however, in order to render the composition of the carbons more homogeneous, and to get rid of the frequent occurrence of hard lumps, which cause a considerable flickering in the light, a more perfect method of preparation has been adopted. The original material is ground up very finely, washed, and a certain proportion of molasses is added to cause the particles to adhere more firmly together. The mass is then passed into a mould, and afterwards dried and finished.

Sometimes, also, a proportion of salts is added, such as soda, potash, strontium, &c., to increase certain properties of the carbons during combustion, either their duration or their luminosity. Again, also, the carbons in some cases after being finished are metallised exteriorly, that is, a thin layer of copper, or other metal, is chemically deposited on the outside. The resistance offered to the electric current in its passage to the carbon point is thus diminished by its being partly conducted along the copper, instead of having to force its way through the carbon only.

Until recently carbons for electric purposes were made almost exclusively in Paris, chiefly by Carré, and also by Gaudouin. In order, however, to keep pace with the increasing demand in this country for carbons, Messrs. Siemens have commenced their manufacture at their works at Charlton, and with apparently a very satisfactory result.

MOTIVE POWER.—The very important part performed by the motor, which supplies the mechanical duty of causing the requisite number of revolutions in the moving element, so as to produce induced currents of the due strength, must not be overlooked, or even underrated, as is often the case. The motors which are generally available may be stated to be the steam engine, the gas engine, and the hydraulic engine or turbine, &c. The one pre-eminent requirement, which is exacted from all, is that of *extreme regularity* of movement, not merely during each revolution, but also during successive revolutions.

To counteract any irregularities on this head, the ordinary precautions of the double cylinder, and of one or two heavy flywheels and a good sensitive governor, can be introduced. But there are also sudden and other irregularities and heavy strains which are thrown upon the motor power from the electric machine itself, especially at the moment of illumination, all of which the motor power is expected to overcome, and that almost immediately; otherwise, very considerable variations and fluctuations in the electric light are the result. For this purpose a very sensitive and quickly acting governor would appear to offer one palliative at least.

It is impossible in the limits of this paper to enter into the respective merits of the different forms of motors. But it may probably be found that water power, especially in the form of a turbine, would afford the most regularity; that the gas engine will be found the most convenient where the horse power required is not great (up to 10-horse power); and that the steam engine will be the one in most cases ready to hand in manufactories, &c., already possessing steam power. But in the last-named case it should be strongly borne in mind that a *special* engine should be devoted to the use of the electric light; and that this duty should not be imposed upon an engine which has other duties to perform, and other machinery to drive; these duties being often of an intermittent character, apart from the irregularities in the running occurring from temporary variations in strain arising from the performance of its ordinary duties.

Approximate of Cost.—Apart from the prime cost of the first outlay of machines, lamps, cables, and motor power, which may readily be ascertained from the manufacturers themselves, there is the question of the working cost of this improved form of illumination, to which intending users would needs have some answer. The most important item in the working expenses is, no doubt, the motor power, and this may be reduced to that of the cost per horse power of the engine employed; a matter which must vary immensely both with the nature of the engine and with the circumstances of the locality and extent of the supply required. The most convenient form in which, therefore, to give any general answer as to the cost on this head would seem to be a proportion between the horse power employed and the amount of light produced, the value per horse power being made to vary with the particular circumstances of each case.

A rough estimate, which the designers of electric machines give, of one indicated horse power per light of about 1,000 standard candles, may hold good where the number of lights from one machine is considerable; but where this is not the case, or where single lights only are considered, a higher proportion of motive power should be taken. Of course, this does not include the reserve of power required to meet the sudden and severe strains to which the motor engine is subjected by the electric machine.

In many parts of France, such as in and around Paris, at Rouen, and in its neighbourhood, electric lighting has been applied regularly during the last two years to many manufactories; amongst others to iron works, to spinning mills, to weaving sheds, &c., and to railway goods yards and other large areas of a similar description; the illumination being almost always from a series of Gramme machines, each producing only one light, or else from one Lontin light-giving machine supplying a considerable number of lamps. It is understood that at several of these localities the result is stated as "three times the amount of light at one-fifth the cost, as compared with the previous illumination by gas." It must, however, be borne in mind that gas in France costs nearly double of what it does in England, and that in almost all the above cases a large amount of steam power existed on the premises, and that probably the small amount required to keep up the electric illumination was considered so insignificant as not to be worth considering as a separate item.

The very considerable first outlay in machines, &c., necessary to obtain the improved illumination, even though cheaper (and that in proportion to the improvement effected), must make individuals hesitate before incurring, each singly, those preliminary expenses incidental to electric lighting.

PROSPECTS OF ELECTRIC LIGHTING.—That the question of this mode of illumination has been practically solved for certain cases, and under certain circumstances, little doubt ought to exist; seeing that, in the case of large areas, such as railway and other yards, and extensive workshops, this has been successfully carried out over an average period of over two years, and under conditions, special and otherwise, which have been deemed satisfactory by the proprietors of those premises—a length of time which may certainly be said to be beyond the term of a scientific experiment. Moreover, has this been done not merely from single light-producing machines, but also from those where a number of lights emanated from a single electric source, and where the actual number and the illuminating power of each was varied at will; thus proving clearly that the electric light is clearly made divisible, and brought under control. Still, that much more will be done, and has to be done, to render electricity completely submissive and pliable to illumination under all circumstances, there can be no hesitation in affirming.

Much is being said as to electricity replacing gas as an illuminant. The fields of each, it may be answered, at present at least, lie apart. Electricity aspires to the illumination of large areas but imperfectly effected by gas lighting, and perhaps to street lighting, which forms but a small and almost unremunerative proportion of the field of gas; while into the special domain of gas lighting, the illumination of private houses, electricity *cannot* in its present form pretend to enter. For (to take one point only) how could each householder be entrusted with the daily duty of seeing that the carbons for every light in his house were in proper order before nightfall? To meet this difficulty alone some indestructible substance, between which to form the light-producing arc, has yet to be discovered. And supposing every difficulty overcome to the introduction of electricity as a general illuminant, is it likely that Parliament would be disposed to deprive existing bodies, constituted under its own Acts for the purpose of general illumination, of their existing privileges, provided they were willing to undertake to distribute the new form of artificial light in lieu of the old?

In closing these remarks on electric lighting as compared with that by gas, the immense advantage in a sanitary point of view which the former possesses over the latter should not be over-

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looked. For, while the first-named causes an inappreciable amount of harm to the purity of the surrounding atmosphere, each gas jet requires as much pure air to dilute sufficiently its deleterious products of combustion as would suffice for several human beings.

A COMPARISON OF THE EDISON AND CHANGY METHODS OF ELECTRIC LIGHTING.

The following is the translation of the first portion of an article which appears in the *Revue Industrielle*, over the esteemed signature of M. Hyppolyte Fontaine :—

"For some time past the scientific and more especially the financial worlds have been engrossed in the consideration of a method of electric lighting which, it is supposed, is immediately to supersede all other systems of artificial lighting. The inventor of the method in question is M. Edison.

"It was an American paper, the *New York Sun*, which brought the news to Europe; and the shares of all the Gas Companies immediately fell, as though the fact were not only true, but actually verified in practice.

"We impatiently awaited a description of this new method which, according to Edison, would allow of the whole of the south portion of New York being lighted by means of a single machine of 500 H.P. At length such a description has come to us, through the intermediary of the *Scientific American*, a paper which is conducted by persons more *au courant* with the question than are the reporters of the *New York Sun*.

"This, then, is the basis upon which rests the new idea of the inventor of the phonograph."

"Mr. Fontaine here gives a translation of the second half of the article which appeared in our last issue, under the heading of 'The Edison Light' :—

"We entirely agree," continues Mr. Fontaine, "with the view taken by our *confrère*, and we should have nothing to add to his conclusions if the pretended invention as thus set forth were not characterised by an absolute absence of novelty.

"This fact is very easily demonstrated.

"On the 27th of February, 1858, M. Jobart, of Brussels, wrote to the *Académie des Sciences*, at Paris, that M. de Changy had just solved the problem of the divisibility of an electric current, and that he had with his own eyes seen a battery of twelve Bunsen elements produce twelve very steady lights, each one independent of the other. M. Jobart added that this result was obtained by means of incandescent platinum spirals, and of a current-dividing *regulator* which prevented fusion.

"No patent was taken out in France. The only document entering into any details of this invention is to be found in the printed collection of Belgian patents. The following is this document *in extenso* :—

"'Letters patent for the industrial application of imperfect conductors in electric lighting, and for the sub-division of the light, obtained. Delivered 19th May, 1858, to M. de Changy.

"'*Description.*—In accordance with the researches which the inventor has undertaken since 1852 on electric lighting by means of the incandescence of imperfect conductors, and notably of platinum wire, and on the possibility of dividing the current proceeding from a single generating source of electricity, after numerous experiments he has obtained proof of the possibility of this division with the help of arrangements the principle of which is as follows:—An electro-magnet placed in communication with a main circuit, and of which the armature is bifurcated between this and the lamp containing the coil of platinum wire, which is to be kept in a state of incandescence, and the other part of the bifurcated wire attached beyond the wire (*sic*), the armature being maintained at a certain distance by an opposing spring, the tension of which can be regulated according to the quantity of current required to pass. The main current, by means of this arrangement, may be divided at as many points as may be desired, even, if needs be, varying the quantity of electricity used at one or more portions of the series of lights, without in any way affecting the other portions. For this purpose, either ordinary electro-magnets which can exert a direct attraction on the armature, or the magnetic action exerted by solenoids upon a moveable piece of iron enclosed within them are employed. In the case of the ordinary electro magnets, these (*sic*) are hollowed out in the form of a cone, the counterpart of which is carried by the armature, in order to establish a connection which is greater or less, according to the distance of the latter. In brief, the principle by means of which the division of the current is obtained depends essentially upon the possibility of allowing the latter to spring beyond the lamp to be lit up, so soon as a maximum of intensity which has been determined beforehand has been obtained.'

"This description is certainly somewhat vague, and the absence of any drawing of the regulator precludes us from completely reconstituting the invention of M. de Changy. Still, the fact remains that the principle upon which it rests is exactly the same as that which is now attributed to Mr. Edison, always supposing that the note taken from the *Scientific American* is correct.

"M. de Changy enclosed his platinum helices in hermetically closed glass tubes previously exhausted of air. We think that Mr. Edison must do the same; for, although oxide of platinum is reduced at a high temperature, platinum heated to whiteness becomes crystalline in the air, rapidly diminishes in sectional area, and breaks into pieces.

"Now, if anyone wishes to know what we think of this affair, we will tell him that the journalistic scribes have no object beyond that of preparing for the creation of a Company with a fabulous capital, which Company will never, to the end of eternity, pay a dividend to its shareholders."

ELECTRICAL GOSSIP.

Electric Lighting in the Provinces.—The Leicester Corporation have decided to ask for powers to use the electric light in that town.

Artificial Heat Applied to Batteries.—In a note to his paper on Byrne's pneumatic battery, reprinted in the *Journal of the Society of Telegraph Engineers*, Mr. Preece says:—"I have found that the application of the heat of a spirit lamp to any form of bichromate battery, especially Grenet's, considerably strengthens the current flowing and intensifies its effects." We believe that the vendors of that class of battery have for a long while notified this fact to their customers. Experimentors would do well to try other forms of battery in the same way.

Rejoicing over Spilt Milk.—An evening contemporary now expresses itself thus:—"The unreasoning scare of the holders of gas shares has afforded some amusement to outsiders, who are laughing heartily at the perplexity of the gentlemen who take ten per cent. and a bonus, and consider themselves public benefactors." This is rather hard upon the gentlemen in question, to say nothing of widows and orphans, seeing that the newspaper writers themselves are mainly responsible for the "unreasoning scare." The loss of some millions of capital is not a subject for laughter, except, perhaps, among people who are *not* gentlemen.

Not so Bad as it Looks.—We are glad to learn, however, in this connection that gas shares have all along been more easy to sell than to buy, and that would-be speculators for the rise have found themselves unable to purchase at the fall. Many of the quoted sales have evidently been misspelt. They should have been described as "sells" to bring down the market.

Catching other People's Hares.—"The announcement," observes the *Echo*, "that Mr. Edison's company intend to supply the electric light on the well-known systems until such time as the latest improvements are perfected, betrays the fact that, after all, Mr. Edison has not overcome certain difficulties." It betrays, too, we should say, a keen eye for business. A rush-light company, if favoured with Mr. Edison's name, would, financially speaking, just now "overcome" any number of "difficulties."

How About the Horse?—Somebody, it appears, has patented a contrivance for taming horses by means of an electro-magneto machine connected with the bit, and set in motion "at pleasure" by the driver. A gentleman in Huntingdonshire writes to say that he devised and used the same thing six months ago, and that he objects to its use being subject to the restrictions of a patent. We cannot agree with him. In London streets, at all events, the bad temper is mostly on the driving box; and, unless there be a provision for reversing the operation "at pleasure" in favour of the tamer animal, we should be sorry to see such a one-sided arrangement in general use. The current is said to pass through the horse's tongue, and, adds the gentleman, "the sensation is no doubt peculiar." We should like him to speak from experience; and so, we think, would the horse.

Another American Puzzle.—It is reported from New York that "a new invention has been patented there for the subdivision of the electric light by two electricians, Messrs. Sawger and Manu. The invention is said to be a very simple one, consisting of a small pencil of carbon little larger than a pin, and connected by wires with an electric machine enclosed *(sic)* in an hermetically sealed glass globe filled with pure nitrogen gas." American reporters are just now nothing unless they are learned; and "hermetically sealed" in "pure nitrogen" is proof positive in this instance. A little more exactness, however, as to the mode of working an electrical machine shut up in a glass globe would

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be acceptable. After all, it may be the grammar and not the learning that is at fault.

DIFFERENCE IN TIME—AND TEMPER.—"How comes it that my Indian telegram is dated Wednesday morning," inquired a perplexed editor, the other day, "and this is only Tuesday afternoon?" "Oh," explained the smart young telegrapher, "that despatch left Simla to-morrow." "If that's your jest," retorted the man of letters, "I wish in real earnest you would use sim'lar despatch every day.

TOO MUCH OF A GOOD THING.—Dr Tidy, with characteristic impetuosity, writes to *The Times* declaring the electric light promises no good to anybody but the opthalmic surgeons, because he carefully examined it for "three hours," and went home with pained eyes and a splitting headache. We should think so, too, if electric lights were like fireworks, a spectacle to be gazed at. Mr. Ansell, of the Eastern Telegraph Company, with equally characteristic good sense, urges the gas companies to exert their utmost efforts to supply a better and purer light. Now, if ever, is their opportunity.

ANOTHER AMERICAN DISCOVERY.—A correspondent writes, says *The Times*:—"Electric lighting appears to have taken another step in advance—namely, the possibility of adjusting the brilliancy of any particular light in the circuit without waste of current by so doing. I understand that a telegraphic confirmation of this fact has been received from Mr. Edison, and is communicated to *Saunders's News Letter* (Dublin) of Thursday. The telegram states, on Mr. Edison's authority, that each electric burner can independently be raised and lowered."

RECENT PATENT.

922. ELECTRIC LAMP-LIGHTING APPARATUS, P. *Dronier*.—*Dated 7th March* 9, 1878.—*(Not proceeded with.)* 2d.

A receiver of glass is placed on a wooden or metal socket, and to the cover is fixed the carbon element of a battery dipping into a solution of bichromate of potash. The zinc element is plunged into it at will by a spring rod. The zinc element is composed of an alloy of zinc and mercury. The conductibility of the carbon with the wire leading to the lighter is insured by placing in the interior of the carbon a fine platinum wire communicating with the lighter. The lighter consists of a thin platinum spiral placed vertically, and provided with a guard of a form that will allow of its serving as a guide for bringing it close to any determined position; the end carries the wick of a small spirit lamp.

TRAFFIC RECEIPTS FOR OCTOBER, 1878.

COMPANIES.	October, 1878. £	October, 1877. £	Increase. £	Decrease. £
Anglo-American Telegraph Company	54,150	49,510	4,640	—
Brazilian Submarine Company	13,138	11,387	1,751	—
Cuba Submarine Company	2,800 estd.	2,933	—	133
Direct Spanish Telegraph Company	1,106	914	192	—
Direct United States Telegraph Company	18,050 estd.	13,480	4,570	—
Eastern Extension Telegraph Company	23,393	21,388	2,005	—
Eastern Telegraph Company	41,678	37,402	4,276	—
Great Northern Telegraph Company	19,737	—	—	—
Submarine Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	10,290	—	—
West Coast of America Telegraph Company	—	—		—
West India Telegraph Company	—	—		—

TELEGRAPH SHARE LIST.

Amount of Issue.	Amount of Share.	Paid on Share.	COMPANY.	Reserve as per last Report.	Dividends 1875. %	1875. %	1876. %	1876. %	1877. %	1877. %	When Payable.	Prices 1875. Highest.	1875. Lowest.	1876. Highest.	1876. Lowest.	1877. Highest.	1877. Lowest.
£3,254,580	Stock	100	Anglo-American	Deferred receiving no dividend until 6 per cent. has been paid to Preferred.		year.	5	4†	3	5	† Div. 5 % per ann. for quarter ending Dec. 31, 1876, 2% for quarter ending Mar. 31, 4 % for quarters ending June 30 and Sept. 30, 6 % for quarter ending Dec. 31, 1877, and 4 % for quarter ending March 31, 1878.	75½	51½	68½	53	62¼	
1,872,710	Stock	100	Do. Preferred B		—	—	10	2	6	6		Crtd	1876.	93	75	88½	
1,872,710	Stock	100	Do. Deferred A		—	—	Nil.	6	Nil.	4		Crtd	1876.	44	29	38	25½
1,300,000	10	All	Brazilian Submarine	120,000	5	5	5	5	5	5	Quarterly.	7¾	6	7¾	5¾	6¾	5⅞
160,000	10	All	Cuba (Limited)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60,000	10	All	Do. 10 per cent. Preference	—	—	—	—	—	—	—	—	—	—	—	—	—	—
116,379	10	9	Direct Spanish (Limited)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
58,430	10	All	Do. 10 per cent. Preference	—	—	—	—	—	—	—	—	—	—	—	—	—	—
65,000	20	All	Direct United States	Nil.	—	Nil.	Nil.	Nil.	Nil.	5	Quarterly.	13	7	11½	6¼	13¾	9½
369,700	10	All	Eastern (Limited)	110,000	5	year.	5	5	5		aJany., April, *July*, Oct.	8	6⅜	7⅝	5	8¼	6⅝
232,000	100	All	Eastern 6 per cent. Debentures	—	—	—	—	—	—	—	—	—	—	—	—	—	—
200,000	100	All	Do. 5 per cent. Debentures	—	—	—	—	—	—	—	—	—	—	—	—	—	—
700,000	10	All	Do. 6 per cent. Preference	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,997,500	10	All	Eastn. Exten. Australasia & China	125,404	5⅓	year.	5	year.	5	year.	aJany., *April*, July, Oct.	8¼	7	7½	5⅜	8	6⅝
320,000	100	All	Eastn. Exten. 6 p.c. Deben. (1875)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
192,680	10	All	German Un. Tl. and Tst.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,500,000	10	All	Globe Telegraph and Trust	Nil.	5	7 4-5	4½	7 5-6	3⅜	7 6-7	bJany., April, *July*, Oct.	6¾	5¼	5⅞	4¼	5¼	4½
1,500,000	10	All	Do. 6 per cent. Preference		6	6	6	6	6	6	Jany., April, July, Oct.	10½	9¾	10½	9¼	10½	9½
150,000	10	All	Great Northern	85,543	5⅝	year.	6⅝	year.	6⅝	year.	5 % intrm. Jan. 1, July 1. Final Dividend April.	11½	7½	9¾	7	8	7
			Shares to Bearer, or can be Regstrd.														
—	25	All	Indo-European	—	—	—	—	—	—	—	—	—	—	—	—	—	—
120,000	10	All	Mediterranean Extension (Lmtd.)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
32,000	10	All	Do. 8 per cent. Preference	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	18	All	Reuter's (Limited)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
65,000	10	All	West India and Panama	16,000	Nil.	Nil.	Nil.	Nil.	1	1	‡ Converted from a 10 %	4¾	1⅜	2½	⅘	3⅝	1⅝
34,563	10	All	Do. 6 per cent. Preference		7/6ac	year.	10/ac	year.	6‡	6	into a 6 % 1st Preference.	12	9	11	7	11	7½
67,500	20	All	Western and Brazilian	7,793	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Half-yearly.	18½	9½	10⅝	4¼	5¾	4½
$1,500,000	$1000	All	Western Union Telegraph 7 per cent. First Mortgage Bonds	—	7	7	7	7	7	7	May, November.	108	102½	109½	105	113	106
£1,030,000	200	All	Do. 6 per cent. Sterling Bonds	Redeeemable by annual drawings at par.	6	6	6	6	6	6	March 1, September 1.	93	86	98	89	101	94

a Year ends March 31st. Interim Dividend of 5 per cent. Final dividend in July.

b Year ends July 18th. Final dividend in July.

COMPANIES.	CLOSING PRICES Nov. 13.		BUSINESS DONE WEEK ENDING NOV. 13. Highest.	Lowest.
Anglo-American	60,	½	60	59½
Do. Preferred	85¾,	86¼	86¼	85½
Do. Deferred	33½,	¾	36	34
Brazilian	6 7-16, 9-16		6 9-16	6½
Cuba	8,	½	—	—
Do. Ten per Cent. Preference	15¼,	¾	15¾	—
Direct Spanish	2,	½	—	—
Do. Ten per Cent. Preference	9½,	10	—	—
Direct United States	12¾,	13¼	13¼	12¾
Eastern	7½,	¾	7¾	7½
Do. Six per Cent. Debenture	103,	105	—	—
Do. Five per Cent. do.	98,	100	99¾	99½
Do. Six per Cent. Preference	10¾,	11¼	11¼	11
Eastern Extension	7¼,	½	7 5-16	7 1-16
Do. Six per Cent. Debenture	103,	105	—	—

COMPANIES.	CLOSING PRICES Nov. 13.		BUSINESS DONE WEEK ENDING NOV. 13. Highest.	Lowest.
German Union	7¾,	8½	8½	8½
Globe Telegraph and Trust	4 15-16, 5 1-16		5 1-16	4 15-16
Do. Six per Cent. Preference	10½,	¾	10¾	10½
Great Northern	7¾,	½	7½	7½
Indo-European	18½,	19½	19½	19½
Mediterranean Extension	2¾,	3½	—	—
Do. Eight per Cent. Preference	8¾,	9½	9	9
Reuter's	9½,	10½	9¾	9¾
Submarine	215,	220	218	215
West India and Panama	1¾,	2¼	2¼	1 15-16
Do. Six per Cent. Preference	8,	½	8½	7½
Western and Brazilian	2¼,	2¾	—	—
West. Union Seven per Cent. 1st Mortgage	108,	112	108	108
Do. Six per Cent. Sterling	100,	102	—	—

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